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HOW TO USE THE SOIL SURVEY REPORT

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SOIL SURVEY OF HUMBOLDT COUNTY, IOWA

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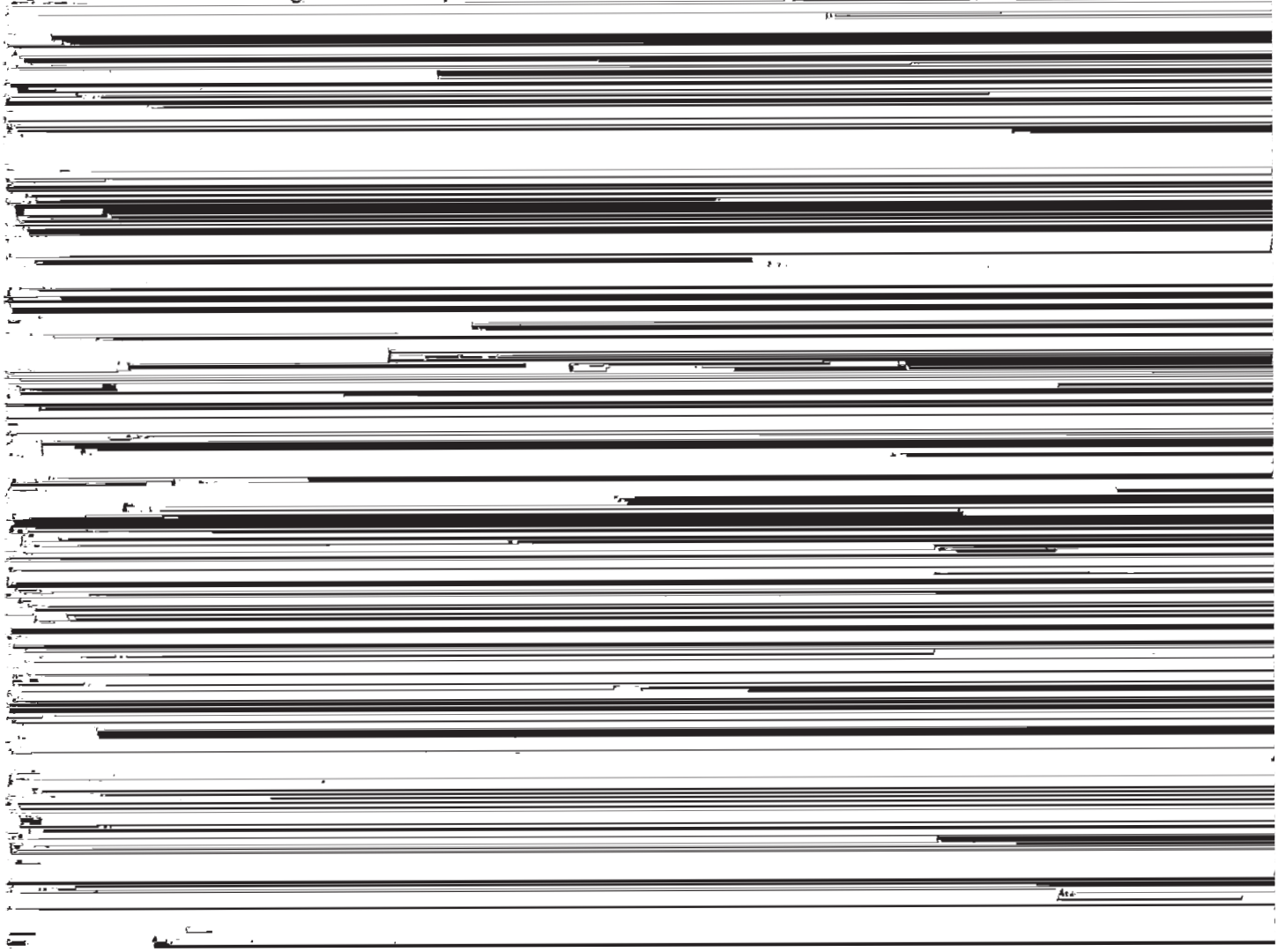
THE SOIL SURVEY of Humboldt County was made by the United States Department of Agriculture in cooperation with the Iowa Agricultural Experiment Station.

Moines lobe was laid down in two substages, the Cary and the Mankato (*12*, *14*). According to this view, Humboldt County was covered by the youngest, or most re-



Des Moines River, or into the Des Moines River below the junction of these two.

The East Fork Des Moines River traverses the county in a north-south direction; the West Fork Des Moines River, in a northwest-southeast direction. Three miles south of Dakota City, the two forks join to form the Des Moines River.

An extensive system of manmade drainage ditches has been dug throughout the county to provide surface drainage and outlets for tile drains.

Climate

Iowa has an extreme midcontinental climate. Continental polar air masses, which dominate the Iowa cli-

The average growing season is May 7 to October 1, a period of 148 days. The average temperature between April 1 and September 30 is about 64° F. The total average precipitation between April 1 and September 30 is approximately 22 inches. A 35-year record shows that the latest frost date was May 31, and the earliest, September 12.

The risk in planting before April 28 or harvesting after October 12 is indicated from records of the station in Pocahontas County, which adjoins Humboldt County on the west, and from records of the West Bend station in Palo Alto County, which is northwest of Humboldt County (*4*). The West Bend station was closed in 1946.

Crops	Acres
Corn, for all purposes	97,037
Oats, threshed or combined	55,065
Soybeans, for all purposes	37,034
Hay, total	24,835
Alfalfa and alfalfa mixtures	12,312
Clover, timothy, and mixtures of clover and grasses	10,935
Other hay	1,588

The numbers of livestock on farms in the county in 1954 were as follows:

Livestock	Number
Cattle and calves	39,868
Milk cows	5,595
Hogs and pigs	114,939
Sheep and lambs	15,895
Horses and mules	421

Soil Survey Methods and Definitions

This section explains how soil maps are made, introduces the reader to some of the terminology used in soil science, and defines terms that have been used to describe the soils. A careful study of the definitions will help the reader to understand the soil descriptions.

FIELD STUDY.—The scientist who makes a soil survey examines soils in the field, classifies the soils in accordance

only with electron microscopes. Soils that are high in clay feel dense and sticky. The soil scientist judges the texture by the feel of the soil when it is rubbed between his thumb and forefinger. In many cases, the texture is checked in the laboratory by mechanical analyses.

Some of the terms used to describe texture are silt loam, loam, clay loam, sandy loam, loamy sand, and clay.

Loam is about 20 percent clay, 40 percent silt, and 40 percent sand. Silt loam has much less sand and more silt. It is about 15 percent clay, 20 percent sand, and at least 50 percent silt. Clay loam contains about equal proportions of sand, silt, and clay. Sandy loam, loamy sand, and sand have increasing percentages of sand, in that order. Clay is more than 40 percent clay-sized particles.

Texture has much to do with the quantity of moisture the soil will hold available to plants, the permeability of the soil, and the ease with which the soil can be cultivated. Silt loams and loams are the most desirable soil textures. Clay soils have restricted movement of air and water and are difficult to work. Sandy soils do not have good water-holding capacity and may be droughty.

Soil consistence.—Consistence is the tendency of the soil to crumble or to stick together. It indicates whether it is easy or difficult to keep the soil open and porous under cultivation. Terms used to describe consistence

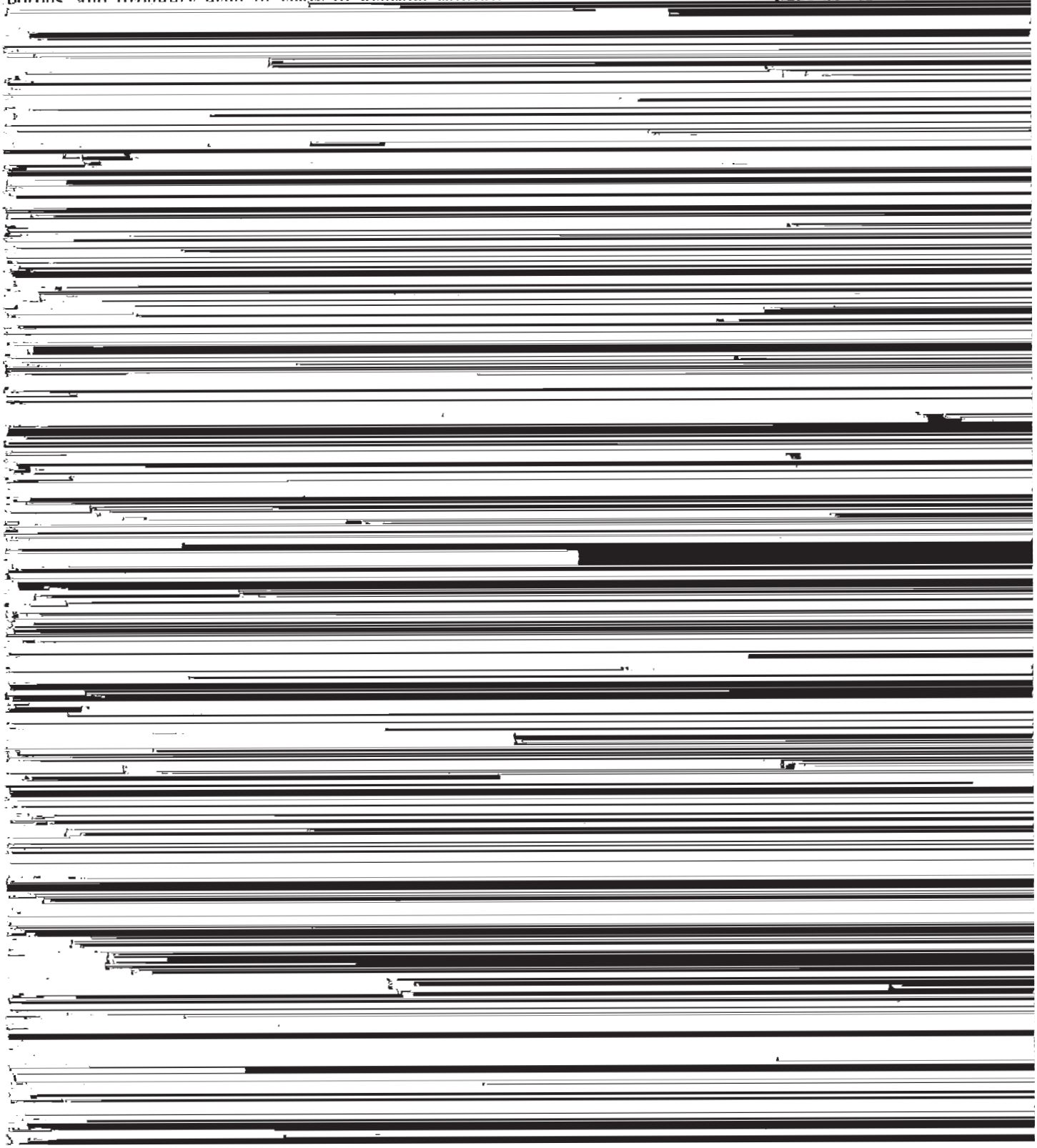
Figure 1.—Profile of Hayden loam (left), Clarion loam (center), and Webster silty clay loam (right). The Webster soil is poorly drained and has a thick, dark-colored surface layer. Clarion loam is well drained and has a surface layer that is thinner than that of Webster silty clay loam and thicker than that of Hayden loam. Hayden loam has a thin surface layer and a higher colored subsurface layer, or A_2 horizon. Hayden loam formed under forest. Clarion loam and Webster silty clay loam formed under prairie.

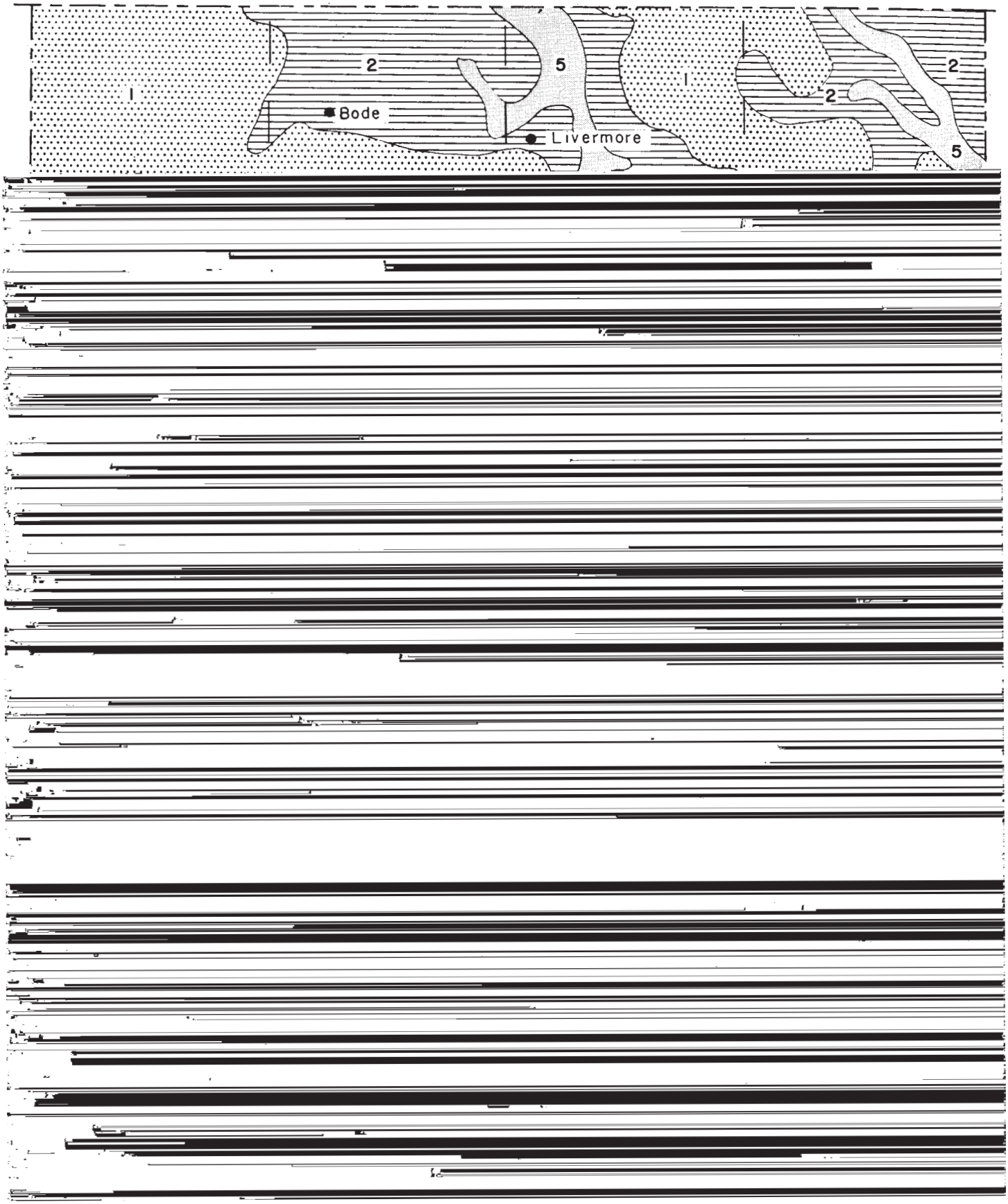
to make them undesirable for ordinary crops. The Lakeville soils are excessively drained.

Somewhat excessively drained soils are those from which water is removed rapidly. They are sandy, very porous, and droughty even in years of average rainfall

mapped in two or more phases, a phase that is not more than slightly eroded, a moderately eroded phase, and perhaps a severely eroded phase.

The characteristics that form the basis for subdivision into phases are significant to the




1
2
5
Bode
Livermore
1
2
2
5

soils in the series. This is followed by short descriptions of each of the soils in the series. The descriptions of the individual soils tell how each soil differs from the typical

management. Table 2 shows the acreage and proportionate extent of all the soils mapped. In table 3, p. 24, the

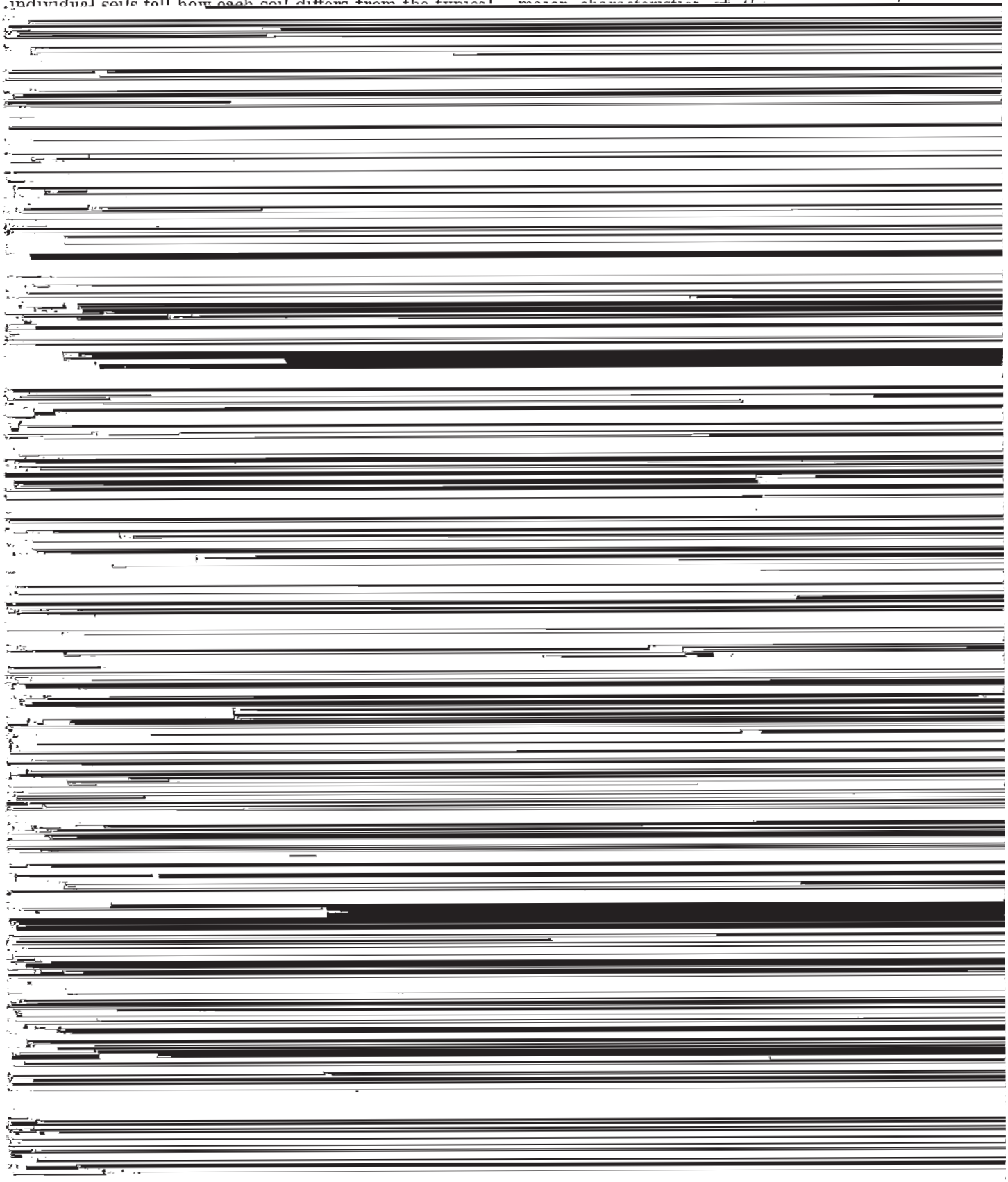
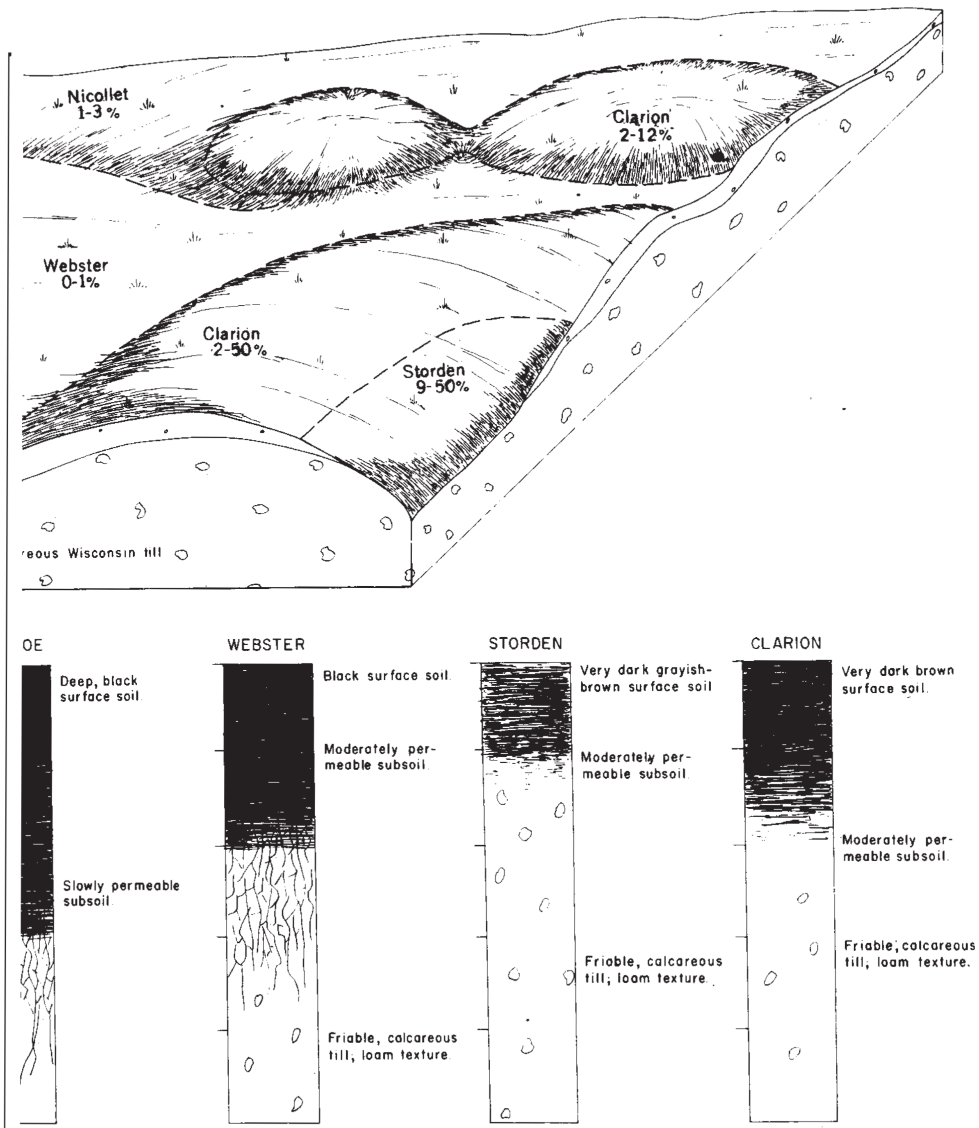


TABLE 2.—*Approximate acreage and proportionate extent of soils*—Continued

Symbol	Soil	Acreage	Percent	Symbol	Soil	Acreage	Percent
TeB	Terril loam, 2 to 5 percent slopes	1, 265	0. 5	WdC2	Waukegan loam, deep over sand and gravel, 5 to 9 percent slopes, moderately eroded	107	(1)
TeC	Terril loam, 5 to 9 percent slopes	59	(1)				
TrA	Truman silt loam, 0 to 2 percent slopes	743	. 3	WmA	Waukegan loam, moderately deep over sand and gravel, 0 to 2 per-		
TrB	Truman silt loam, 2 to 5 percent						



o one another. The native vegetation and parent material are indicated. The schematic the thickness of the soil layers, and the permeability of the subsoil.

Ankeny sandy loam, 5 to 9 percent slopes (AnC).—This soil is gently rolling. Although water from the adjoining hillsides deposits soil material on it, erosion may become active. Consequently, erosion control is needed if row crops are grown. Diversion terraces may have to be constructed on the slopes above to divert runoff and to prevent gullying and further deposition.

This soil is suitable for cultivation, but crop yields are limited by droughtiness.

Capability subclass IIIs; management group 10.

Clarion series

The Clarion series consists of well-drained soils that developed from calcareous glacial till. The native vegetation consisted of prairie grasses. These soils occur in both large and small areas on the uplands. The slopes

Clarion loam, 2 to 5 percent slopes, moderately eroded (CaB2).—The dark-colored surface layer of this soil is only 3 to 6 inches thick. The slopes are irregular and undulating. There is a slight erosion hazard.

This soil is highly productive, although it is somewhat lower in nitrogen than Clarion loam, 2 to 5 percent slopes. It is suitable for frequent row cropping if adequate erosion control practices are applied.

Capability subclass IIe; management group 6.

Clarion loam, 5 to 9 percent slopes (CaC).—This soil is highly productive. It has gently rolling slopes. It is suitable for frequent row cropping if erosion is controlled.

Capability subclass IIIe; management group 11.

Clarion loam, 5 to 9 percent slopes, moderately eroded (CaC2).—Only 3 to 6 inches of the original dark-

Clarion loam, thin solum, 2 to 5 percent slopes (CnB).—This soil is generally surrounded by other Clarion soils. It is only 12 to 24 inches deep over the calcareous glacial till. The slopes are irregular and undulating, and there is a slight erosion hazard.

silty sediment when flooded. It includes many old stream channels or oxbows that cannot be crossed with farm machinery. These channels are sometimes full of water. The soil in them is commonly very clayey.

This soil would be productive if it were drained and

Copas series[4]

The Copas series consists of nearly level, dark-colored, well-drained soils that are underlain by limestone bedrock at depths of 18 to 30 inches. These soils are in upland drainageways or on terraces along major streams.[5] They are sometimes flooded in periods of high rainfall. They formed from alluvium or glacial outwash material. The principal native vegetation was prairie grasses.

The following profile of Copas loam is representative of the Copas series.

Surface soil—
0 to 11 inches, very dark gray loam; moderately rapid permeability.
Subsoil—
11 to 22 inches, dark-brown and dark yellowish-brown loam.
Substratum—
22 inches+, limestone bedrock.

These soils are slightly droughty. They have moderately rapid permeability and a low moisture-holding capacity. They are generally low in available nitrogen, low in available phosphorus, and medium to low in available potassium. They are neutral to medium acid.

Copas loam (Cv).—This soil has practically no erosion hazard, but it is droughty and consequently is not suited to intensive use for cultivated crops. The severity of the droughtiness depends on the depth to bedrock.

This soil responds to fertilizer, but because of the droughtiness it would be uneconomical to apply large amounts of fertilizer. Crop yields are low.

Capability subclass IIs; management group 5.

Cullo series

The Cullo series consists of dark-colored, nearly level, poorly drained soils that developed from waterworked glacial till or local alluvium. These soils are in slight depressions but are not rimmed by Harpster soils, as are the Glencoe soils, which occur in a similar position. The native vegetation consisted of swamp grasses and sedges.

The following profile of Cullo silty clay loam is representative of the Cullo series.

Surface soil—
0 to 13 inches, black, moderately slowly permeable silty clay loam.
Subsurface soil—
13 to 16 inches, very dark gray and dark gray, moderately permeable silt loam.
Subsoil—
16 to 35 inches, olive-gray, slowly permeable, heavy silty clay loam; olive and olive-gray mottles.
Parent material—
35 to 50 inches, dark-gray, moderately permeable loam;

tilizer and is moderately productive. If well managed, it can be kept in good tilth. Removing excess water and maintaining fertility are the principal management problems.

Very small areas of this soil are shown on the soil map by conventional symbols.

Capability subclass IIIw; management group 7.

Dickinson series

The Dickinson series consists of sandy, dark-colored, excessively drained, nearly level to hilly soils on uplands or terraces. These soils developed from sandy material. The native vegetation consisted of prairie grasses.

The following profile of Dickinson fine sandy loam, on a slope of 3 percent, is representative of the Dickinson series.

Surface soil—
0 to 10 inches, very dark gray fine sandy loam; moderately rapid permeability.
Subsoil—
10 to 30 inches, dark-brown sandy loam; moderately rapid permeability.
Parent material—
30 inches+, yellowish-brown loamy sand and sand; rapid permeability.

In eroded areas the surface soil is not so dark colored.

Dickinson soils have rapid to moderately rapid permeability and a low water-holding capacity. They are generally low in available nitrogen, phosphorus, and potassium. Lime needs are variable.

Dickinson fine sandy loam, 0 to 2 percent slopes (DkA).—The parent material of this soil was mostly wind-deposited sandy material but included some sandy glacial drift. The profile is like the representative profile, except that the dark-colored surface layer is 10 to 14 inches thick.

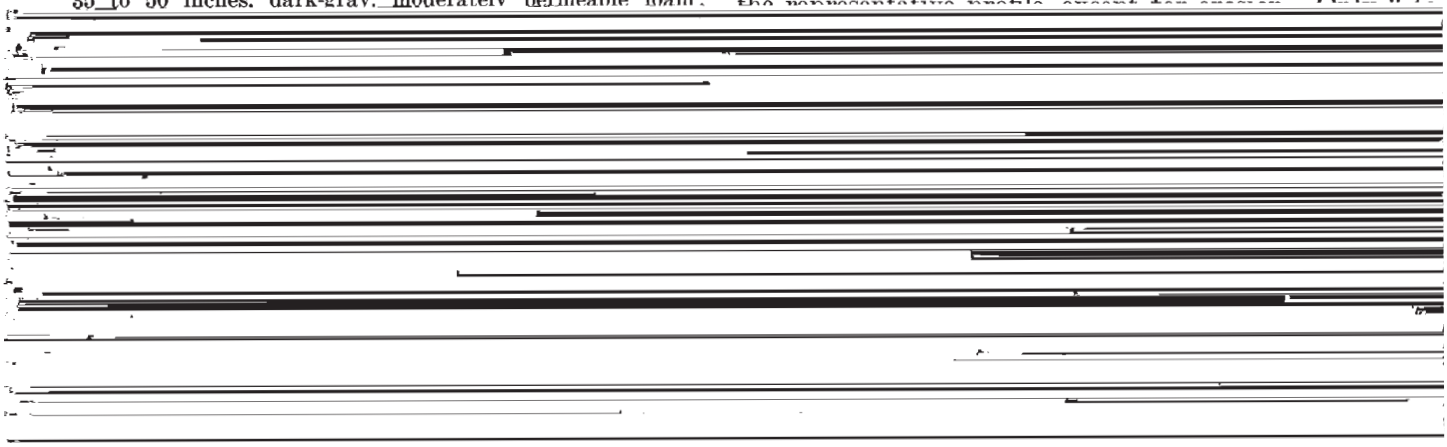
This soil is suitable for cultivated crops. It responds to fertilizer but, because of droughtiness, produces only moderate yields. Wind erosion is a hazard. Blowing sand damages young plants in some years.

Capability subclass IIIs; management group 9.

Dickinson fine sandy loam, 2 to 5 percent slopes (DkB).—This soil is undulating and is subject to erosion by both wind and water. It is suitable for cultivated crops. Because of droughtiness, crop yields are only moderate.

Capability subclass IIIs; management group 9.

Dickinson fine sandy loam, 5 to 9 percent slopes, moderately eroded (DkC2).—The profile of this soil is like the representative profile except for erosion. Only 2 to



Dickinson fine sandy loam, 15 to 20 percent slopes, severely eroded (DkE3).—The surface layer of this hilly soil is less than 6 inches thick. Otherwise, the profile is like the representative profile.

This soil is best used for permanent pasture. It is not suitable for cultivated crops, because of droughtiness, strong slopes, and the hazard of wind and water erosion.

Some moderately eroded soil is included.

Capability subclass VIs; management group 17.

Dickinson sandy loam, bench position, 0 to 2 percent slopes (DtA).—This soil developed from sandy material deposited by water on nearly level stream terraces. The dark-colored surface layer is 7 to 14 inches thick, and the underlying material includes strata of gravel as well as sand.

This soil can be used for cultivated crops, but yields are low because of droughtiness. Cultivated areas are subject to wind erosion.

Capability subclass IIIs; management group 9.

Dickinson sandy loam, bench position, 2 to 5 percent slopes (DtB).—This soil is like Dickinson sandy loam, bench position, 0 to 2 percent slopes, except that it has undulating slopes. It is suitable for limited use for cultivated crops. Crop yields are low because of droughtiness. Cultivated areas are subject to both wind and water erosion.

Capability subclass IIIs; management group 9.

Dickinson sandy loam, bench position, 5 to 9 percent slopes, moderately eroded (DtC2).—This soil is like Dickinson sandy loam, bench position, 0 to 2 percent slopes, except that it has rolling slopes and the dark-colored surface layer is only 3 to 6 inches thick. It can be used for cultivated crops, but crop yields are very low because of droughtiness. Probably the best use for it is permanent hay or pasture. Cultivated areas are subject to both wind and water erosion.

Capability subclass IVs; management group 13.

Dickinson sandy loam, bench position, 9 to 15 percent slopes, moderately eroded (DtD2).—This soil is like Dickinson sandy loam, bench position, 0 to 2 percent slopes, except that it has rolling slopes and the surface layer is less than 6 inches thick. It is not suitable for cultivated crops, because it is very droughty and very low in productivity and erodes easily. Permanent pasture is the best use for it.

Capability subclass VIs; management group 17.

Dundas series

The Dundas series consists of dark-colored, poorly drained soils that developed from glacial till. These soils occur in rather small, nearly level areas in the uplands near woods. The native vegetation consisted of prairie grasses and trees.

The following profile of Dundas silty clay loam is representative of the Dundas series.

Surface soil—
0 to 8 inches, black, moderately slowly permeable silty clay loam.
Subsurface soil—
8 to 13 inches, dark-gray, slowly permeable silty clay loam.
Subsoil—
13 to 39 inches, dark grayish-brown and dark-gray, very slowly permeable, gritty silty clay to heavy silty clay loam.
Parent material—
39 to 45 inches, grayish-brown, moderately permeable loam.

The Dundas soils are medium acid to strongly acid. They are generally low in available nitrogen and medium in available phosphorus and potassium. The water-holding capacity is high, and the permeability is slow to very slow. The clay in the subsoil restricts the movement of air and water.

Dundas silty clay loam (Du).—If this soil is drained, it is suitable for frequent row cropping. It is highly productive. Because it occurs in rather small areas, it is ordinarily cropped along with the surrounding soils. Some areas are still in forest.

This soil responds to applications of fertilizer. Under a high level of management, good tilth is easy to maintain. The chief management problems are drainage and maintenance of fertility.

Capability subclass IIw; management group 3.

Farrar series

The Farrar series consists of undulating to rolling, somewhat excessively drained sandy soils of the uplands. These soils developed in sandy, wind-deposited material that is 14 to 40 inches thick over glacial till. They are moderately dark colored where not eroded. The native vegetation consisted of prairie grasses. The following profile of Farrar fine sandy loam, on a slope of 3 percent, is representative of the Farrar series.

Surface soil—
0 to 12 inches, very dark grayish-brown to dark-brown, moderately rapidly permeable fine sandy loam.
Subsoil—
12 to 24 inches, dark yellowish-brown, moderately rapidly permeable sandy loam.
Substratum—
24 inches+, yellowish-brown, moderately permeable loam (till).

The Farrar soils are generally low in available nitrogen and phosphorus and medium in available potassium. They are slightly droughty and have a low moisture-holding capacity. Wind erosion is severe at times.

Farrar fine sandy loam, 2 to 5 percent slopes (FaB).—This soil is undulating and has a slight erosion hazard. It is slightly droughty, even in seasons of normal rainfall. It is easy to work and is suitable for cultivated crops, but yields are not high. Blowing sand sometimes damages young plants. Leaving crop residues on the surface will reduce wind damage. The soil responds favorably to applications of complete fertilizer.

Capability subclass IIs; management group 5.

Farrar fine sandy loam, 5 to 9 percent slopes, moderately eroded (FaC2).—This soil is gently rolling and has a moderate erosion hazard. It has a surface layer that is only 3 to 6 inches thick. It is droughty, even in seasons of normal rainfall. It can be used for row crops, but yields are not high. If row cropped, it should be contoured and terraced.

Capability subclass IIIs; management group 10.

Farrar fine sandy loam, 9 to 15 percent slopes, moderately eroded (FaD2).—This soil is rolling and has a severe erosion hazard. The surface layer is only 3 to 6 inches thick. The soil is droughty, even in seasons of normal rainfall. Its use for grain is limited. Permanent hay is probably the best use for it.

Capability subclass IVs; management group 13.

Garmore series

The Garmore series consists of moderately well drained, dark-colored soils that developed from glacial till. Soils of this series occur in general soil area 3 in the southwestern part of the county. The slopes are both concave and convex and are nearly level to undulating. The native vegetation consisted of prairie grasses. The following profile of Garmore silt loam, on a slope of 2 percent, is representative of the Garmore series.

Surface soil—
0 to 15 inches, black to very dark gray, moderately permeable silt loam.
Subsoil—
15 to 49 inches, dark grayish-brown and dark-brown, moderately permeable clay loam; very dark gray mottles.
Parent material—
49 to 75 inches, yellowish-brown, moderately permeable loam; calcareous below a depth of 62 inches; limestone bedrock at a depth of 14 feet.

The Garmore soils are generally low in available nitrogen and phosphorus and medium in available potassium. They are strongly acid. They have a high water-holding capacity.

Garmore silt loam (Ga).—This is one of the most productive soils in the county. It is suitable for frequent row cropping. On intensively cultivated slopes of 2 to 3 percent, it has a very slight erosion hazard. It is seldom, if ever, too wet for crops, and it seldom, if ever, needs tile drainage.

Capability class I; management group 1.

Glencoe series

The Glencoe series consists of very dark colored, pothole soils that are very poorly drained. These soils are nearly level and occur in depressions in the uplands. Unless they are drained, they are often ponded. The parent material was waterworked glacial till or local alluvium. Swamp grasses and sedges were the native vegetation. The Glencoe soils are generally rimmed with Harpster soils (see fig. 4, page 9). The following profile of Glencoe silty clay loam is representative of the Glencoe series.

Surface soil—
0 to 20 inches, black, slowly permeable silty clay loam.
Subsoil—
20 to 49 inches, black to very dark gray, slowly to very slowly permeable, light silty clay to silty clay loam.
Parent material—
49 to 56 inches, gray to light gray, moderately [illegible]

obtained. Yields are high in the drier years, but yields averaged over a long period are only moderate. This soil occurs in small areas and is usually cropped along with the surrounding soils. Very small areas are shown on the soil map by conventional symbols.

Capability subclass IIIw; management group 7.

Harpster series

The Harpster series consists of nearly level, poorly drained soils that have developed from glacial till, outwash, or alluvium. These soils are high in lime. When they are dry, the surface color in cultivated fields is distinctly grayer than the color of the surrounding soils. The native vegetation consisted of prairie grasses. The following profile of Harpster loam, on a slope of 1 percent, is representative of the Harpster series.

Surface soil—
0 to 9 inches, dark-gray, moderately permeable loam; very high in lime.
Subsoil—
9 to 22 inches, dark-gray to grayish-brown, moderately slowly permeable clay loam; very high in lime.
Parent material—
22 to 60 inches, olive-gray to grayish-brown, moderately permeable loam; very high in lime.

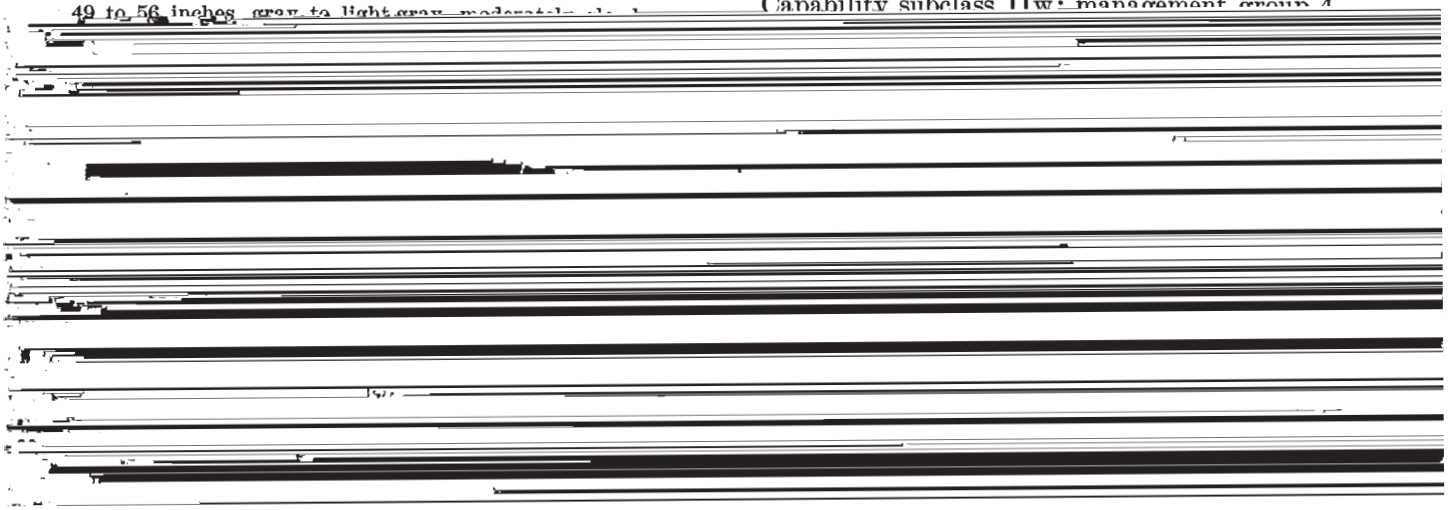
The Harpster soils are generally medium in available nitrogen and very low in available phosphorus and potassium. Some areas are deficient in iron and other minor elements.

Harpster loam (Ha).—This soil occurs as a rim around potholes and depressions in the uplands (see fig. 4, p. 9) or as a low rise within a pothole or depression. There is a serious potassium deficiency for most crops grown on this soil. Corn yields may be 20 to 30 bushels per acre lower than those from the surrounding soils, unless enough fertilizer is applied to correct the extreme deficiences in phosphorus and potassium. Many areas do not supply enough iron for soybeans.

This soil is suitable for frequent row cropping if properly drained and fertilized. Tile drainage is needed. Unless this soil is artificially drained, it is often too wet to be cultivated. The response to potash and phosphate fertilizers is good. Lime should not be applied.

Most areas of this soil are small and are cropped along with the surrounding soils. Very small areas are shown on the soil map by conventional symbols.

Capability subclass IIw; management group 4



yields may be 15 to 20 bushels lower than on the surrounding soils unless enough fertilizer is applied to correct the phosphorus and potassium deficiencies.

This soil is suitable for frequent row cropping if properly drained and fertilized. It responds well to applications of phosphate and potash. Yields are moderate.

Capability subclass IIw; management group 4.

Hayden series

These are well-drained, moderately dark colored to light colored, upland soils developed from glacial till. The slopes range from undulating to steep. These soils generally occur along streams near timbered areas. Figure 4, p. 9, shows how the Hayden soils occur in relationship to other soils. Hardwoods were the native vegetation. A few sand and gravel spots may occur. Representative of the Hayden series is the following profile of Hayden loam, on a slope of 3 percent.

Surface soil—
0 to 5 inches, very dark gray, moderately permeable loam.
Subsurface soil—
5 to 9 inches, dark grayish-brown, moderately permeable loam.
Subsoil—
9 to 38 inches, dark-brown, moderately slowly permeable loam to clay loam.
Parent material—
38 to 50 inches, yellowish-brown, moderately permeable loam.

Generally, the Hayden soils are low in available nitrogen and phosphorus and medium in potassium. They are medium acid. They have a moderately high water-holding capacity.

Hayden loam, 2 to 5 percent slopes (HdB).—This undulating soil is highly productive and is suitable for frequent row cropping if measures are taken to control erosion. It is lighter colored than the Clarion soils and is lower in nitrogen. Under a high level of management, it is easy to keep in good tilth. The response to fertilizer is good.

Capability subclass IIe; management group 6.

Hayden loam, 5 to 9 percent slopes, moderately probably semipermanent hay or pasture. Row crops should be grown only occasionally. This soil is suitable for producing timber.

Capability subclass IVe; management group 14.

Hayden soils, 20 to 50 percent slopes (HsF).—This soil has steep slopes and a severe erosion hazard. The surface layer is only 3 to 6 inches thick. The soil is too steep for cultivation and it is best for permanent pasture, as woodland, or as a habitat for wildlife.

Capability subclass VIIe; management group 18.

Huntsville series

The Huntsville series consists of dark-colored, bottomland soils that are imperfectly drained. These soils are nearly level and are flooded in periods of heavy rainfall, which come most often in spring. The native vegetation was a mixture of prairie grasses and trees. The following profile of Huntsville silt loam is representative of the series.

Surface soil—
0 to 19 inches, very dark gray, moderately permeable silt loam.
Subsoil—
19 to 44 inches, light olive-brown, moderately permeable silty clay loam to clay loam.
Substratum—
44 to 60 inches, light olive-brown and grayish-brown, moderately rapidly permeable sandy loam.

The Huntsville soils have a medium to high water-holding capacity. They are moderately permeable. Normally, they are medium in available nitrogen and potassium and low in available phosphorus.

Huntsville silt loam, channeled (Hv).—This soil is frequently flooded. Its use is limited to permanent hay or pasture. There are oxbows and old stream channels that are not crossable with farm machinery. Sometimes the oxbows and channels are filled with water, and in many of them the soil is very clayey.

Capability subclass Vw; management group 15.

Huntsville silt loam (Hu).—This soil is flooded less often than Huntsville silt loam, channeled. If floods are controlled, it is highly productive and is suitable for fre-

The Kato soils are generally medium in available nitrogen, phosphorus, and potassium.

Kato loam, moderately deep over sand and gravel, 0 to 2 percent slopes (KmA).—The profile of this soil is like the representative profile described. Generally, the depth to sand and gravel is 24 to 30 inches. This soil is slightly wet in rainy seasons and slightly droughty in others. It seldom needs tile drainage. Tile installation may be difficult because of caving. This soil is suitable for frequent row cropping, but, because it is slightly droughty, is only moderately productive. It responds to applications of complete fertiiizer. Erosion is not a problem.

[illegible]

Lakeville gravelly loam, 5 to 9 percent slopes, moderately eroded (LaC2).—Most of this soil is gently rolling, but some milder slopes are included. If this soil is cultivated, it has a moderate hazard of both wind and water erosion. It is very droughty; consequently, it does not respond well to applications of fertilizer. Its best use is permanent hay or pasture.

Capability subclass IVs; management group 13.

Lakeville gravelly loam, 9 to 20 percent slopes, moderately eroded (LaE2).—This soil is rolling to hilly. If it is cultivated, it is subject to severe erosion by wind and water. Because of extreme droughtiness, its best use is permanent pasture.

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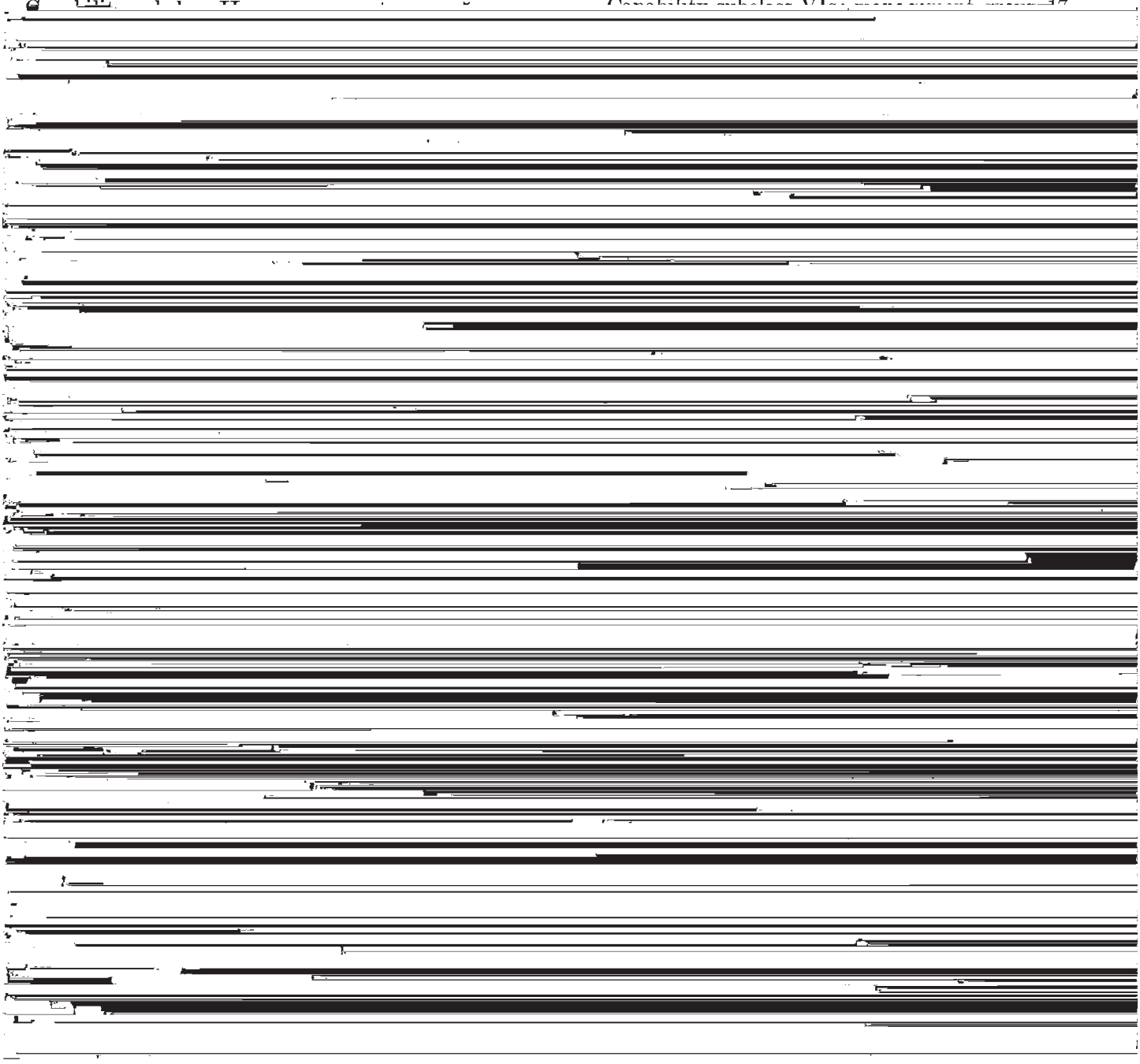
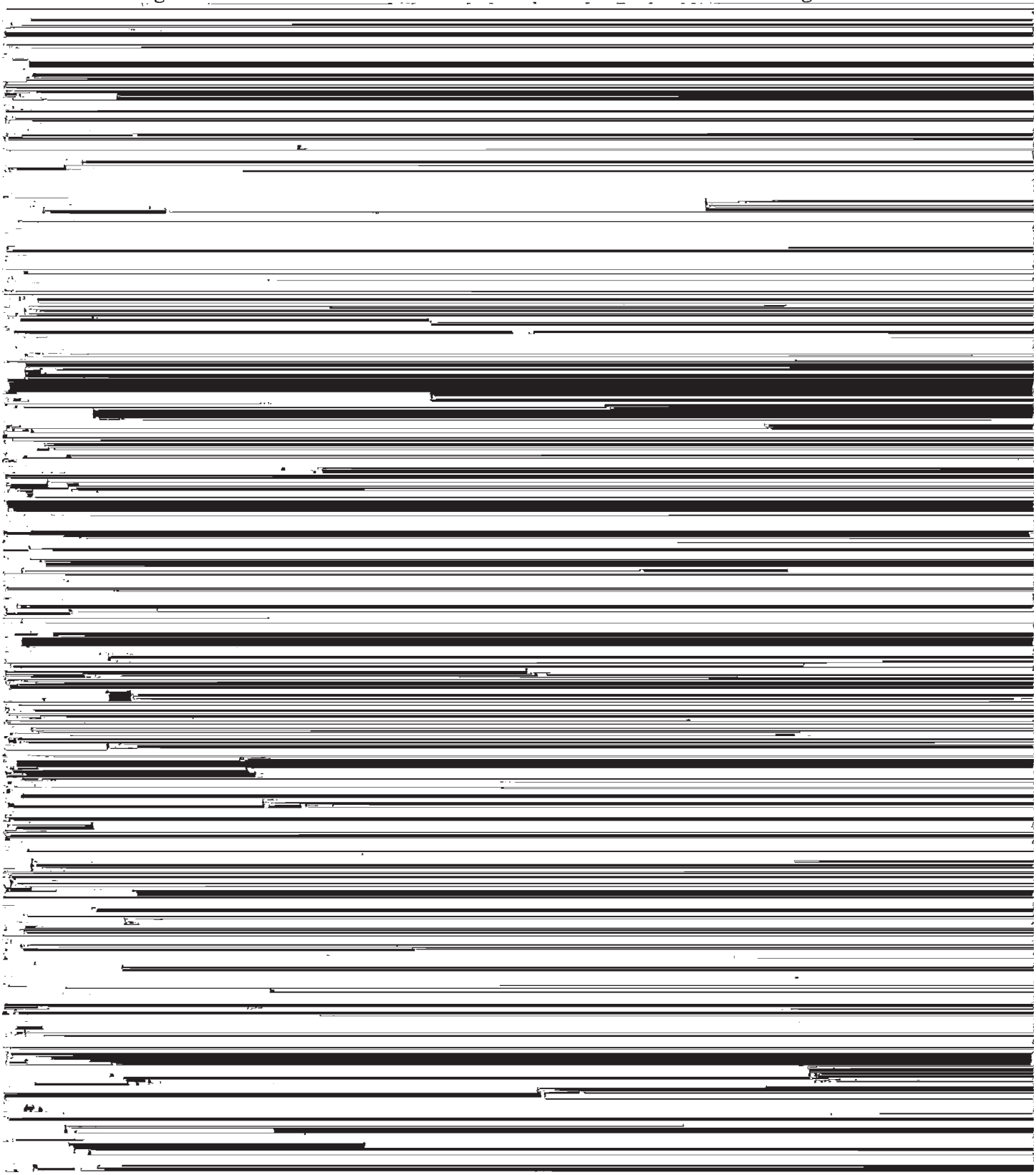


Lamont fine sandy loam, 15 to 20 percent slopes, moderately eroded (LfE2).—The surface layer of this soil is thinner and lighter colored than the one described in

Lester loam, 9 to 15 percent slopes, moderately eroded (LmD2).—This soil has a surface layer that is only 3 to 6 inches thick. It is rolling and has a severe erosion



Marshan series

The soils of the Marshan series are poorly drained, level to nearly level, black soils that are underlain by sand and gravel. They are on outwash terraces and along minor streams. Swamp grasses and sedges were the native vegetation. Most areas that are not artificially

Some areas of Muck and Mucky peat are very acid. The reaction is variable. These soils are generally high in available nitrogen and generally low in available phophorus and potassium. They may be deficient in trace elements for some crops.

Muck, shallow (Mw).—The profile of this soil is like the representative profile. The muck is 10 to 25 inches thick

in the county. The following profile of Nicollet loam, on a slope of 2 percent, is representative of the series.

Surface soil—
0 to 14 inches, black, moderately permeable loam.
Subsoil—
14 to 31 inches, very dark grayish-brown and dark grayish-brown, moderately permeable clay loam.
Parent material—
31 inches+, dark grayish-brown and very dark grayish-brown, moderately permeable loam; dark-brown mottles; calcareous below a depth of 40 inches.

The Nicollet soils are generally medium to low in available nitrogen, low in phosphorus, and medium in potassium. They have a high water-holding capacity.

Nicollet loam (Nc).—This soil is suitable for frequent row cropping and is among the most productive soils in the county. Ordinarily, there is no erosion problem, but there is a slight erosion hazard on slopes of 3 percent. Slopes of 2 to 3 percent may erode if intensively row cropped. In periods of high rainfall, the nearly level areas are sometimes slightly too wet for crops, but tile is seldom used. Only a few areas are tile drained.

Under a high level of management, good tilth is easy to maintain. This soil responds well to applications of complete fertilizer. It is in row crops most of the time.

Capability class I; management group 1.

Okoboji series

The Okoboji series consists of nearly level, dark-colored soils that are very poorly drained. These soils developed from waterworked glacial till or local alluvium. They are in large and small depressions or potholes and are generally surrounded, or rimmed, with Harpster soils. Unless artificially drained, these soils are ponded. The native vegetation was swamp grasses and sedges. The following profile of Okoboji silt loam is representative of the series.

Surface soil—
0 to 10 inches, very dark gray, moderately permeable silt loam.
Subsoil—
10 to 30 inches, black, moderately slowly permeable, light silty clay loam.
Parent material—
30 inches+, gray to olive, moderately permeable, calcareous silt loam; light olive-brown mottles.

The Okoboji soils have a very high water-holding capacity. They are generally medium in available nitrogen and potassium and low in available phosphorus.

Okoboji silt loam (Ok).—This soil is highly productive and suitable for frequent row cropping if well drained artificially. Tile drains work well if suitable outlets at adequate depth can be obtained. However, tile drainage alone will not prevent flooding after heavy rains. Open intakes to tile or shallow surface ditches are needed to remove the surface water and to prevent drowning of crops. Surface ditches are probably better. Lime is seldom needed. The response to complete fertilizer is good.

Partially drained areas are used for pasture. Undrained areas are suitable only as wildlife habitats.

Capability subclass IIIw; management group 7.

Okoboji series, imperfectly drained variant

This imperfectly drained Okoboji variant occurs in the uplands in depressions that appear to be sinkholes. These depressions occur only in general soil area 3, where the limestone bedrock is nearer the surface than in the other general soil areas. The depressions have been filled with very dark colored soil material washed from the surrounding areas. In periods of high rainfall, they are temporarily flooded. The native vegetation consisted of prairie grasses. A representative profile of Okoboji silt loam, imperfectly drained variant, follows.

Surface soil—
0 to 30 inches, very dark gray to black, moderately permeable silt loam.
Subsoil—
30 to 50 inches, dark grayish-brown to grayish-brown, moderately permeable silt loam to light clay loam.

This soil is normally medium in available nitrogen and potassium and low in available phosphorus. It has a high water-holding capacity.

Okoboji silt loam, imperfectly drained variant (Op).—This soil is slightly wet in some years because of flooding or poor drainage, and crops may be damaged. Some kind of surface drainage may be needed to remove excess water. If this soil is well drained artificially, it is highly productive. It is suitable for frequent row cropping, but, because it occurs in small areas, it is usually cropped along with the surrounding soils. Under a high level of management, good tilth is easy to maintain. The response to complete fertilizer is good.

Capability subclass IIw; management group 3.

Orio series

The Orio series consists of poorly drained, nearly level, dark soils that developed in waterworked glacial material. They occur in potholes or depressions. The areas are both large and small. The native vegetation was swamp grasses and sedges. The following profile of Orio fine sandy loam is representative of the Orio soils in Humboldt County.

Surface soil—
0 to 8 inches, very dark gray, moderately permeable fine sandy loam.
Subsurface soil—
8 to 20 inches, very dark gray to dark gray, moderately permeable sandy loam to light loam.
Subsoil—
20 to 45 inches, very dark gray to gray, slowly permeable sandy clay loam; light-gray and dark-brown mottles.
Parent material—
45 to 60 inches, dark-gray, moderately permeable sandy loam.

The Orio soils have a medium water-holding capacity. They are generally medium to low in available nitrogen and low in available phosphorus and potassium.

Orio fine sandy loam (Or).—Unless this soil is artificially drained, it ponds. Tile drains work only fairly well, because of the slow permeability of the soil. Nevertheless, this soil is generally tiled along with the surrounding soils. Surface water should be removed by open intakes to tile or by shallow surface drains.

After artificial drainage has been installed, this soil is suitable for frequent row cropping. The surrounding soils are row cropped intensively, and this soil is generally cropped along with them, but it is only moderately productive at best. If this soil is well drained, it responds well to applications of complete fertilizer.

Capability subclass IIIw; management group 7.

Plattville series

The Plattville series consists of imperfectly drained, nearly level, dark-colored soils that are underlain by limestone bedrock at depths of 36 to 60 inches. These soils developed in loamy alluvium or outwash in minor

lines should be placed closer together than in the Webster soils. Shallow surface ditches or open intakes to tile are needed to remove excess surface water as rapidly as possible.

Very small areas of this soil are shown on the soil map

toured or terraced, but average yields will be only moderate. Rather heavy applications of fertilizers will be needed to insure the best yields. Phosphate fertilizer is particularly needed for alfalfa. This soil does not need lime.

Capability subclass IIIe; management group 12.

Storden loam, 15 to 20 percent slopes, moderately eroded (StE2).—This soil is hilly and has a severe erosion hazard. It is best used for permanent hay or pasture.

Capability subclass IVe; management group 14.

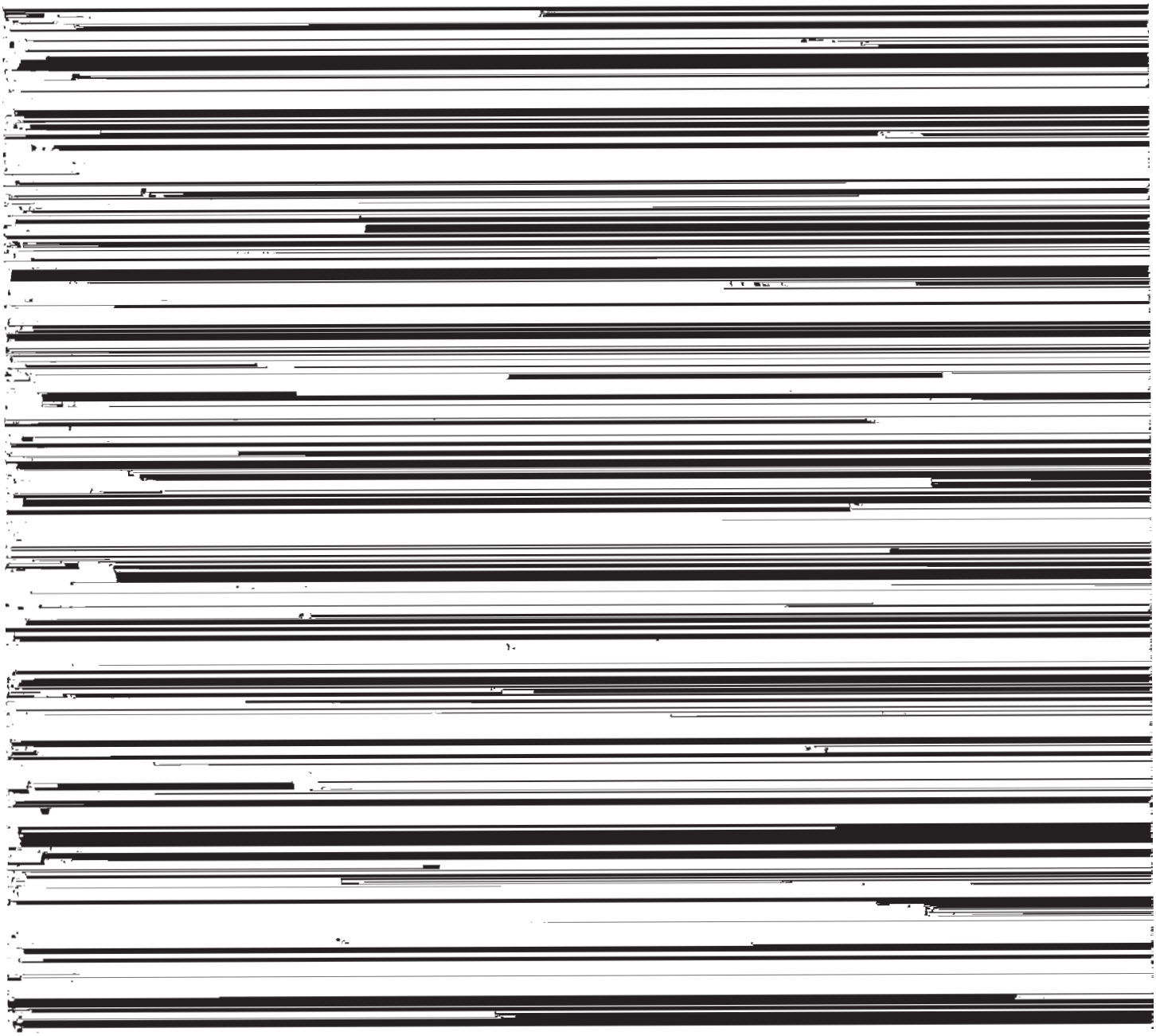
Storden loam, 20 to 30 percent slopes, severely eroded (StF3).—In some areas of this soil, less than 3 inches of the former surface layer remains. The slopes are steep and unsuitable for cultivation. Permanent pasture is the best use for this soil.

Terril loam, 5 to 9 percent slopes (TeC).—This soil is gently rolling. It has a moderate erosion hazard, and diversions may be needed to control runoff from bordering slopes. This soil should be contoured when planted to row crops. It is suitable for frequent row cropping and is highly productive.

Capability subclass IIIe; management group 11.

Truman series

The Truman series consists of well-drained soils that developed from silty, water-deposited material. These soils occur on outwash terraces along streams. They are nearly level to hilly. All except the nearly level soil are subject to erosion. The stronger the slope, the greater the erosion hazard. The native vegetation consisted of



3 to 6 inches thick. It is hilly and has a severe erosion hazard; therefore, it is best suited to semipermanent hay or pasture. Row crops should not be grown more often than 1 year in 6.

Capability subclass IVe; management group 14.

Wabash series

The Wabash series consists of poorly drained, black soils that are frequently flooded. These soils are on level to slightly depressed first bottoms adjacent to streams. The level of their water table is often the same as the level of the stream water. Swamp grasses and sedges native vegetation. The following profile of Wacousta silt loam is representative of the series.

Surface soil—
0 to 8 inches, black, moderately permeable silt loam.
Subsoil—
8 to 20 inches, dark olive-gray to dark-gray, moderately slowly permeable, calcareous silty clay loam; yellowish-brown mottles.
Parent material—
20 inches+, light olive-gray and olive-gray, moderately permeable, calcareous, light silty clay loam to silt loam; yellowish-brown mottles.

The Wacousta soils are generally medium in available

Waukegan loam, moderately deep over sand and gravel, 0 to 2 percent slopes. It is gently undulating, and there is a slight erosion hazard. It is droughty, even in years of normal rainfall. The soil is suitable for cultivated crops, but average yields are only moderate.

Webster series

The Webster series consists of nearly level, poorly drained, black soils of the uplands. The soils have developed from glacial till or from waterworked glacial material overlying glacial till. The native vegetation

TABLE 3.—*Major characteristics*

Map symbol	Soil	Position on landscape	Parent material	Native vegetation
Ad	Alluvial land	Bottom land	Alluvium	Willow brush and young trees.
Am	Ames loam	Upland	Glacial till	Trees
AnB	Ankeny sandy loam, 2 to 5 percent slopes	Foot slopes	Sandy colluvium	Grass
AnC	Ankeny sandy loam, 5 to 9 percent slopes	Foot slopes	Sandy colluvium	Grass
CaB	Clarion loam, 2 to 5 percent slopes	Upland	Glacial till	Grass
CaB2	Clarion loam, 2 to 5 percent slopes, moderately eroded	Upland	Glacial till	Grass
CaC	Clarion loam, 5 to 9 percent slopes	Upland	Glacial till	Grass
CaC2	Clarion loam, 5 to 9 percent slopes, moderately eroded.	Upland	Glacial till	Grass
CaD2	Clarion loam, 9 to 15 percent slopes, moderately eroded	Upland	Glacial till	Grass
CaE2	Clarion loam, 15 to 20 percent slopes, moderately eroded	Upland	Glacial till	Grass
CaF2	Clarion loam, 20 to 30 percent slopes, moderately eroded	Upland	Glacial till	Grass
CaG	Clarion loam, 30 to 50 percent slopes	Upland	Glacial till	Grass
CnB	Clarion loam, thin solum, 2 to 5 percent slopes	Upland	Glacial till	Grass
CnC2	Clarion loam, thin solum, 5 to 9 percent slopes, moderately eroded.	Upland	Glacial till	Grass
Co	Colo silt loam	Bottom land	Alluvium	Swamp grass and sedges.
Cp	Colo silt loam, channeled	Bottom land	Alluvium	Swamp grass and sedges.
Cr	Colo silty clay loam	Bottom land	Alluvium	Swamp grass and sedges.
Cs	Colo silty clay loam, channeled	Bottom land	Alluvium	Swamp grass and sedges.
CtB	Colo-Terril complex, 1 to 5 percent slopes	Foot slopes and bottom land.	Alluvium	Grass
CtC	Colo-Terril complex, 5 to 9 percent slopes	Foot slopes and bottom land.	Alluvium	Grass
Cv	Copas loam	Terraces and upland drainageways.	Alluvium or outwash over limestone.	Grass
Cu	Cullo silty clay loam	Upland depressions	Waterworked glacial till or local alluvium.	Swamp grass and sedges.
DkA	Dickinson fine sandy loam, 0 to 2 percent slopes	Upland	Eolian sand or sandy glacial drift.	Grass
DkB	Dickinson fine sandy loam, 2 to 5 percent slopes	Upland	Eolian sand or sandy glacial drift.	Grass
DkC2	Dickinson fine sandy loam, 5 to 9 percent slopes, moderately eroded.	Upland	Eolian sand or sandy glacial drift.	Grass
DkD2	Dickinson fine sandy loam, 9 to 15 percent slopes, moderately eroded.	Upland	Eolian sand or sandy glacial drift.	Grass
DkE3	Dickinson fine sandy loam, 15 to 20 percent slopes, severely eroded.	Upland	Eolian sand or sandy glacial drift.	Grass
DtA	Dickinson sandy loam, bench position, 0 to 2 percent slopes.	Terraces	Sandy alluvium	Grass
DtB	Dickinson sandy loam, bench position, 2 to 5 percent slopes.	Terraces	Sandy alluvium	Grass
DtC2	Dickinson sandy loam, bench position, 5 to 9 percent slopes, moderately eroded.	Terraces	Sandy alluvium	Grass
DtD2	Dickinson sandy loam, bench position, 9 to 15 percent slopes, moderately eroded.	Terraces	Sandy alluvium	Grass
Du	Dundas silty clay loam	Upland	Glacial till	Grass and trees
FaB	Farrar fine sandy loam, 2 to 5 percent slopes	Upland	Eolian sand over glacial till.	Grass
FaC2	Farrar fine sandy loam, 5 to 9 percent slopes, moderately eroded.	Upland	Eolian sand over glacial till.	Grass
FaD2	Farrar fine sandy loam, 9 to 15 percent slopes, moderately eroded.	Upland	Eolian sand over glacial till.	Grass
Ga	Garmore silt loam	Upland	Glacial till	Grass
Gc	Glencoe silty clay loam	Upland depressions	Local alluvium or waterworked glacial till.	Swamp grass and sedges.
Ha	Harpster loam	Upland	Glacial till	Grass
Hb	Harpster loam, sand and gravel substratum	Upland or terraces	Outwash or alluvium	Grass
Hc	Harpster silt loam	Terraces	Alluvium	Grass

of the mapping units

Organic-matter content	Surface soil		Subsoil texture [2]	Permeability classes	Natural drainage
	Relative color [1]	Texture [2]			
Variable	Variable	Variable	Variable	Variable	Variable.
Medium	Moderately dark	Medium	Moderately fine to fine	Very slow	Poor.
Medium	Dark	Moderately coarse	Moderately coarse	Rapid	Somewhat excessive.
Medium	Dark	Moderately coarse	Moderately coarse	Rapid	Somewhat excessive.
High	Dark	Medium	Medium	Moderate	Good.
Medium	Moderately dark	Medium	Medium	Moderate	Good.
High	Dark	Medium	Medium	Moderate	Good.
Medium	Moderately dark	Medium	Medium	Moderate	Good.
Medium	Moderately dark	Medium	Medium	Moderate	Good.
Medium	Moderately dark	Medium	Medium	Moderate	Good.
Medium	Moderately dark	Medium	Medium	Moderate	Good.
Medium	Moderately dark	Medium	Medium	Moderate	Good.
Medium	Dark	Medium	Medium	Moderate	Good.
Medium	Moderately dark	Medium	Medium	Moderate	Good.
High	Dark	Medium	Moderately fine	Moderately slow	Poor.

TABLE 3.—*Major characteristics*

Map symbol	Soil	Position on landscape	Parent material	Native vegetation
HdB	Hayden loam, 2 to 5 percent slopes	Upland	Glacial till	Trees
HdC2	Hayden loam, 5 to 9 percent slopes, moderately eroded	Upland	Glacial till	Trees
HdD2	Hayden loam, 9 to 15 percent slopes, moderately eroded	Upland	Glacial till	Trees
HdE2	Hayden loam, 15 to 20 percent slopes, moderately eroded.	Upland	Glacial till	Trees
HsF	Hayden soils, 20 to 50 percent slopes	Upland	Glacial till	Trees
Hu	Huntsville silt loam	Bottom land	Alluvium	Grass
Hv	Huntsville silt loam, channeled	Bottom land	Alluvium	Grass and trees
KmA	Kato loam, moderately deep over sand and gravel, 0 to 2 percent slopes.	Terraces	Glacial outwash	Grass
KmB	Kato loam, moderately deep over sand and gravel, 2 to 5 percent slopes.	Terraces	Glacial outwash	Grass
KdA	Kato loam, deep over sand and gravel, 0 to 2 percent slopes.	Terraces	Glacial outwash	Grass
KdB	Kato loam, deep over sand and gravel, 2 to 5 percent slopes.	Terraces	Glacial outwash	Grass
LaC2	Lakeville gravelly loam, 5 to 9 percent slopes, moderately eroded.	Upland	Gravelly stratified glacial drift.	Grass
LaE2	Lakeville gravelly loam, 9 to 20 percent slopes, moderately eroded.	Upland	Gravelly stratified glacial drift.	Grass
LfB	Lamont fine sandy loam, 2 to 5 percent slopes	Upland	Eolian material over glacial till.	Trees
LfC2	Lamont fine sandy loam, 5 to 9 percent slopes, moderately eroded.	Upland	Eolian material over glacial till.	Trees
LfD2	Lamont fine sandy loam, 9 to 15 percent slopes, moderately eroded.	Upland	Eolian material over glacial till.	Trees
LfE2	Lamont fine sandy loam, 15 to 20 percent slopes, moderately eroded.	Upland	Eolian material over glacial till.	Trees
LmB	Lester loam, 2 to 5 percent slopes	Upland	Glacial till	Grass and trees
LmC2	Lester loam, 5 to 9 percent slopes, moderately eroded	Upland	Glacial till	Grass and trees
LmD2	Lester loam, 9 to 15 percent slopes, moderately eroded	Upland	Glacial till	Grass and trees
LmE2	Lester loam, 15 to 20 percent slopes, moderately eroded	Upland	Glacial till	Grass and trees
LsF	Lester soils, 20 to 30 percent slopes	Upland	Glacial till	Grass and trees
LsG	Lester soils, 30 to 50 percent slopes	Upland	Glacial till	Grass and trees
Lu	LeSueur loam	Upland	Glacial till	Grass and trees
Md	Marshan silty clay loam, deep over sand and gravel	Terraces	Glacial outwash	Swamp grass and sedges.
Mm	Marshan silty clay loam, moderately deep over sand and gravel.	Terraces	Glacial outwash	Swamp grass and sedges.
Mu	Muck, moderately shallow	Upland	Organic matter	Swamp grass and sedges.
Mw	Muck, shallow	Upland	Organic matter	Swamp grass and sedges.
Mx	Mucky peat, deep	Upland	Organic matter	Swamp grass and sedges.
My	Mucky peat, moderately shallow	Upland	Organic matter	Swamp grass and sedges.
Mz	Mucky peat, shallow	Upland	Organic matter	Swamp grass and sedges.
Nc	Nicollet loam	Upland	Glacial till	Grass
Ok	Okoboji silt loam	Upland	Waterworked glacial till or local alluvium.	Swamp grass and sedges.
Op	Okoboji silt loam, imperfectly drained variant	Upland	Local alluvium	Grass
Or	Orio fine sandy loam	Upland	Glacial drift	Swamp grass and sedges.
Pv	Plattville loam	Upland and terraces	Alluvium or outwash over limestone.	Grass
Ro	Rolfe loam	Upland	Waterworked glacial till or local alluvium.	Swamp grass and sedges.
SgB	Sogn loam, 2 to 5 percent slopes	Terraces	Glacial drift over limestone.	Grass
StD2	Storden loam, 9 to 15 percent slopes, moderately eroded	Upland	Glacial till	Grass
StE2	Storden loam, 15 to 20 percent slopes, moderately eroded	Upland	Glacial till	Grass

of the mapping units—Continued

Organic-matter content	Surface soil		Subsoil texture [2]	Permeability classes	Natural drainage
	Relative color [1]	Texture [2]			
Medium	Moderately dark	Medium	Moderately fine	Moderately slow	Good.
Medium	Moderately dark	Medium	Moderately fine	Moderately slow	Good.
Medium	Light	Medium	Moderately fine	Moderately slow	Good.
Low	Light	Medium	Moderately fine	Moderately slow	Good.
Low	Light	Medium	Moderately fine	Moderately slow	Good.
High	Dark	Medium	Moderately fine	Moderate	Imperfect.
High	Dark	Medium	Moderately fine	Moderate	Imperfect.
High	Dark	Medium	Moderately fine	Moderate	Imperfect.
High	Dark	Medium	Moderately fine	Moderate	Imperfect.
High	Dark	Medium	Moderately fine	Moderate	Imperfect.
Low	Moderately dark	Moderately coarse	Coarse	Rapid	Excessive.
Low	Moderately dark	Moderately coarse	Coarse	Rapid	Excessive.
Low	Moderately dark	Moderately coasre	Moderately coarse	Moderately rapid	Excessive.
Low	Moderately dark	Moderately coarse	Moderately coarse	Moderately rapid	Excessive.
Low	Light	Moderately coarse	Moderately coarse	Moderately rapid	Excessive.
Low	Light	Moderately coarse	Moderately coarse	Moderately rapid	Excessive.
Medium	Moderately dark	Medium	Moderately fine	Moderate	Good.
Medium	Moderately dark	Medium	Moderately fine	Moderate	Good.
Low	Moderately dark	Medium	Moderately fine	Moderate	Good.
Medium	Moderately dark	Medium	Moderately fine	Moderate	Good.
Medium	Moderately dark	Medium	Moderately fine	Moderate	Good.
Medium	Moderately dark	Medium	Moderately fine	Moderate	Good.
Medium	Dark	Medium	Moderately fine	Moderate to moderately slow.	Imperfect.
High	Very dark	Moderately fine	Moderately fine	Moderately slow	Poor.
High	Very dark	Moderately fine	Moderately fine	Moderately slow	Poor.
High	Very dark	(3)	Medium	Moderate	Very poor.
High	Very dark	(3)	Medium	Moderate	Very poor.
High	Very dark	(3)	Medium	Moderate	Very poor.
High	Very dark	(3)	Medium	Moderate	Very poor.
High	Very dark	(3)	Medium	Moderate	Very poor.
High	Dark	Medium	Moderately fine	Moderate	Imperfect.
High	Dark	Medium	Moderately fine	Moderately slow	Very poor.
High	Dark	Medium	Moderately fine	Moderate	Imperfect.
Medium	Dark	Moderately coarse	Moderately fine	Slow	Poor.
High	Dark	Medium	Moderately fine	Moderate	Imperfect.
High	Dark	Medium	Fine	Very slow	Poor.
Medium	Dark	Medium	Limestone bedrock	Moderate	Good.
Low	Moderately dark	Medium	Medium	Moderate	Excessive to good.
Low	Light	Medium	Medium	Moderate	Excessive to good.
Low	Light	Medium	Medium	Moderate	Excessive to good.
Low	Light	Medium	Medium	Moderate	Excessive to good.

TABLE 3.—*Major characteristics*

Map symbol	Soil	Position on landscape	Parent material	Native vegetation
TeA	Terril loam, 0 to 2 percent slopes	Foot slopes	Local alluvium	Grass
TeB	Terril loam, 2 to 5 percent slopes	Foot slopes	Local alluvium	Grass
TeC	Terril loam, 5 to 9 percent slopes	Foot slopes	Local alluvium	Grass
TrA	Truman silt loam, 0 to 2 percent slopes	Terraces	Alluvium	Grass
TrB	Truman silt loam, 2 to 5 percent slopes	Terraces	Alluvium	Grass
TrC2	Truman silt loam, 5 to 9 percent slopes, moderately eroded.	Terraces	Alluvium	Grass
TrD2	Truman silt loam, 9 to 15 percent slopes, moderately eroded.	Terraces	Alluvium	Grass
TrE2	Truman silt loam, 15 to 20 percent slopes, moderately eroded.	Terraces	Alluvium	Grass
Wa	Wabash silty clay	Bottom land	Alluvium	Swamp grass and sedges.
Wb	Wabash silty clay, channeled	Bottom land	Alluvium	Swamp grass and sedges.
Wc	Wacousta silt loam	Upland depressions	Waterworked glacial till or local alluvium.	Swamp grass and sedges.
WmA	Waukegan loam, moderately deep over sand and gravel, 0 to 2 percent slopes.	Terraces	Glacial outwash	Grass
WmB	Waukegan loam, moderately deep over sand and gravel, 2 to 5 percent slopes.	Terraces	Glacial outwash	Grass
WmC2	Waukegan loam, moderately deep over sand and gravel, 5 to 9 percent slopes, moderately eroded.	Terraces	Glacial outwash	Grass
WmD2	Waukegan loam, moderately deep over sand and gravel, 9 to 15 percent slopes, moderately eroded.	Terraces	Glacial outwash	Grass
WdA	Waukegan loam, deep over sand and gravel, 0 to 2 percent slopes.	Terraces	Glacial outwash	Grass
WdB	Waukegan loam, deep over sand and gravel, 2 to 5 percent slopes.	Terraces	Glacial outwash	Grass
WdC2	Waukegan loam, deep over sand and gravel, 5 to 9 percent slopes, moderately eroded.	Terraces	Glacial outwash	Grass
Wy	Webster silty clay loam	Upland	Waterworked glacial till or glacial till.	Swamp grasses
Wz	Webster silty clay loam, calcareous variant	Upland	Waterworked glacial till or glacial till.	Swamp grasses

[redacted]

of the mapping units—Continued

Organic-matter content	Surface soil		Subsoil texture [2]	Permeability classes	Natural drainage
	Relative color [1]	Texture [2]			
High	Dark	Medium	Medium	Moderate	Moderately good.

Figure 7.—**Drainage ditch, Norway Township, typical of the ditches used as tile outlets to improve soil drainage.**

contains the largest amounts of organic matter and plant nutrients.

Erosion by water can be controlled by contouring, terracing, and stripcropping; by planting meadow crops; and by installing diversion ditches. Wind erosion can be reduced by leaving oat stubble, cornstalks, or other plant remains on the surface or partly buried. This prac-

Crop rotation.—A suitable crop rotation is part of good soil management. No one rotation is best suited to all farms or soils. A rotation suitable for a farmer with adequate capital and a broad livestock program is not suitable for a farmer having little livestock or capital. Sloping soils that erode readily need rotations different from those used on level soils that do not erode.

Suggested crop rotations or land use, with accompanying erosion control practices, are given in the subsection, Management groups, and in table 5. Use of suitable rotations and appropriate soil conserving practices will insure maximum long-time productivity, reduce erosion losses to a reasonable minimum, and help to maintain a satisfactory level of organic matter. Fertilization according to needs shown by soil tests is essential if a rotation is to have its maximum beneficial effect.

In choosing a crop rotation for a farm or field, consider the character of the soils, their potential productivity, and the erosion control required. The fertility of the soils, the need for livestock feed and pasture, and the economic situation must also be considered.

Soil Productivity

Before choosing a cropping system for a soil, some estimate of the soils productivity is needed. Table 5 is

TABLE 4.—*Content of nitrogen, phosphorus, and potassium in 1,575 soil samples*

Soil samples	Samples rated according to content of—												
	Nitrogen[1]				Phosphorus[2]				Potassium[2]				
	Very low	Low	Medium	High	Very low	Low	Medium	High	Very low	Low	Low to medium	Medium	High
Noncalcareous ..... *percent*	6	62	27	4	16	60	18	6	0	6	43	39	12
Calcareous ..... *percent*	1	52	36	11	49	41	8	2	3	10	38	37	12

[1] For all samples tested during 1953 and 1954. [2] For all samples tested prior to July 1, 1954.

The average yields in table 5 are thought to be fairly reliable appraisals of what can be expected from the soils of the county. They are based on research data from experimental farms, on the experience of farmers, and on the judgment of soil scientists and the agronomy staff at Iowa State University. Year-to-year fluctuations in yields are normal and are to be expected. A few farmers, using the best techniques and management known today, can be expected to obtain yields 10 to 15 percent higher than the estimated yields. Of course, introduction of new crop varieties, of better fertilization practices, or of other improved methods may make necessary a revision of the averages in the future.

Planning the Farm

After you have identified the different soils, noted the pected crop yields; and capability of the soils as defined in the capability classification used by the Soil Conservation Service.

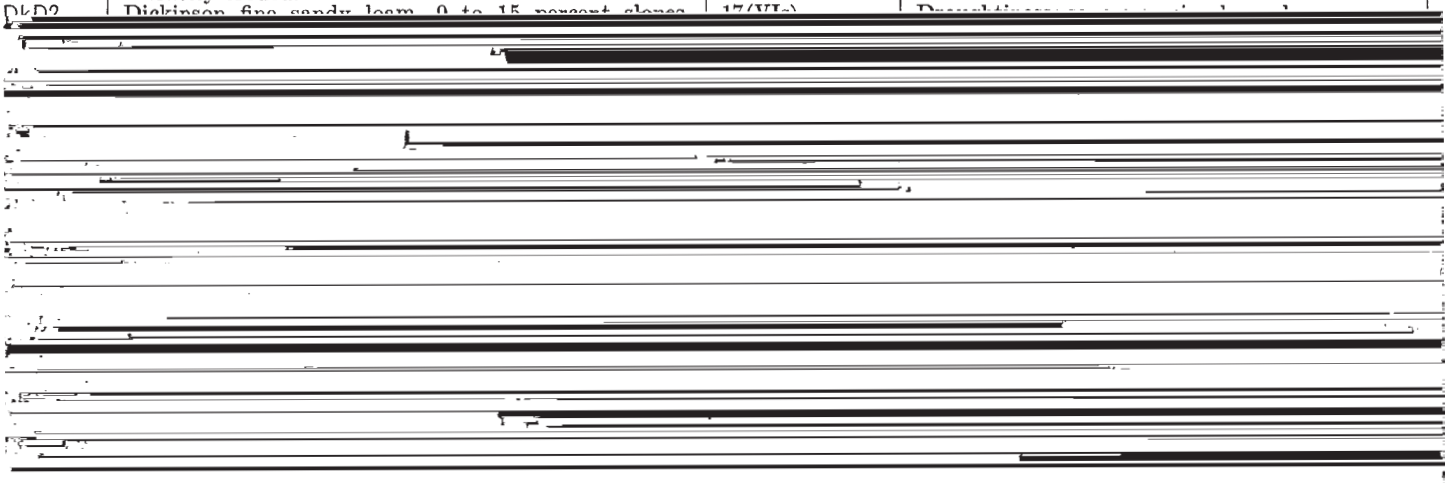
If drainage is a problem, perhaps that is the place to start. If alfalfa and brome meadows are to be established, the lime requirements should be checked in advance. Field rearrangements may be accomplished more conveniently when an area is in meadow. Terraces can be conveniently constructed on meadow that will be plowed for corn. If contouring is to be established on land in first-year corn, do not plow out all of the meadow before planting the corn. Leave strips of sod on the headlands and in places where machinery will be turned to help keep these areas safe from erosion.

Capability Groups of Soils

TABLE 5.—*Suggested rotations, principal*

[Absence of yield figure indicates that the soil is not

Map symbol	Soil	Management group and capability class and subclass	Most serious limitations
Ad	Alluvial land	15(Vw)	Flooding
Am	Ames loam	7(IIIw)	Ponding and wetness
AnB	Ankeny sandy loam, 2 to 5 percent slopes	5(IIs)	Droughtiness
AnC	Ankeny sandy loam, 5 to 9 percent slopes	10(III)s	Droughtiness; moderate erosion hazard
CaB	Clarion loam, 2 to 5 percent slopes	6(IIe)	Slight erosion hazard
CaB2	Clarion loam, 2 to 5 percent slopes, moderately eroded	6(IIe)	Slight erosion hazard
CaC	Clarion loam, 5 to 9 percent slopes	11(IIIe)	Moderate erosion hazard
CaC2	Clarion loam, 5 to 9 percent slopes, moderately eroded	11(IIIe)	Moderate erosion hazard
CaD2	Clarion loam, 9 to 15 percent slopes, moderately eroded.	12(IIIe)	Severe erosion hazard
CaE2	Clarion loam, 15 to 20 percent slopes, moderately eroded.	14(IVe)	Severe erosion hazard
CaF2	Clarion loam, 20 to 30 percent slopes, moderately eroded.	16(VIe)	Severe erosion hazard
CaG	Clarion loam, 30 to 50 percent slopes	18(VIIe)	Severe erosion hazard
CnB	Clarion loam, thin solum, 2 to 5 percent slopes	6(IIe)	Slight erosion hazard
CnC2	Clarion loam, thin solum, 5 to 9 percent slopes, moderately eroded.	11(IIIe)	Moderate erosion hazard
Co	Colo silt loam	2(IIw)	Some flooding; wetness
Cp	Colo silt loam, channeled	15(Vw)	Severe flooding; wetness
Cr	Colo silty clay loam	2(IIw)	Some flooding; wetness
Cs	Colo silty clay loam, channeled	15(Vw)	Severe flooding; wetness
CtB	Colo-Terril complex, 1 to 5 percent slopes	3(IIw)	Wetness; gullying
CtC	Colo-Terril complex, 5 to 9 percent slopes	11(IIIe)	Wetness; erosion hazard
Cv	Copas loam	5(IIs)	Droughtiness
Cu	Cullo silty clay loam	7(IIIw)	Ponding; wetness
DkA	Dickinson fine sandy loam, 0 to 2 percent slopes	9(IIIs)	Droughtiness
DkB	Dickinson fine sandy loam, 2 to 5 percent slopes	9(IIIs)	Droughtiness; slight erosion hazard
DkC2	Dickinson fine sandy loam, 5 to 9 percent slopes, moderately eroded.	13(IVs)	Droughtiness; moderate erosion hazard
DkD2	Dickinson fine sandy loam, 9 to 15 percent slopes	17(VIe)	Droughtiness; severe erosion hazard



management practices, and expected yields

suitable for the crop, or the crop is not commonly grown]

Suggested land use and principal accompanying management practices		Expected average crop yields per acre under a high level of management [2]			
Rotations [1] and other land use	Management	Corn	Soybeans	Oats	Hay [3]
		Bushels	*Bushels*	*Bushels*	*Tons*
Permanent pasture or woodland	None				
Same as surrounding soils	Tile and surface drainage if soil is cultivated	45	17	35	1. 8
Corn, oats, and meadow	None	42	15	35	2. 0
Corn for 2 years, oats, and meadow	Contouring	42	15	35	2. 0
Corn, oats, and meadow for 2 years	Contouring	40		30	1. 8
Corn for 2 years, oats, and meadow	Terracing	40		30	1. 8
Corn for 2 years, oats, and meadow for 2 years	None	72	28	52	3. 0

TABLE 5.—*Suggested rotations, principal management*

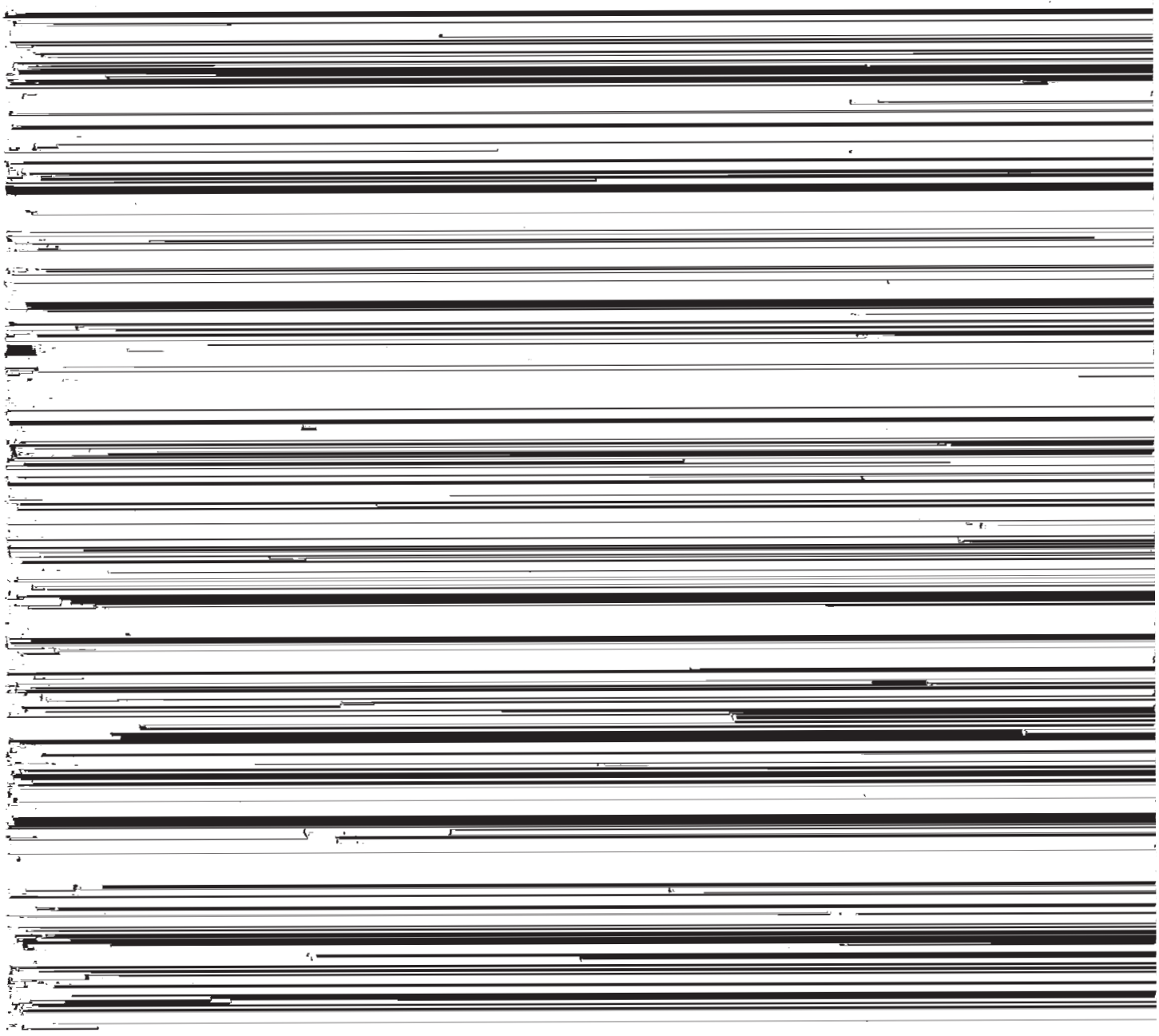
Map symbol	Soil	Management group and capability class and subclass	Most serious limitations
Ga	Garmore silt loam	1(I)	None
Gc	Glencoe silty clay loam	7(IIIw)	Ponding; wetness
Ha	Harpster loam	4(IIw)	Wetness; low fertility
Hb	Harpster loam, sand and gravel substratum	4(IIw)	Wetness; low fertility
Hc	Harpster silt loam	4(IIw)	Wetness; low fertility
HdB	Hayden loam, 2 to 5 percent slopes	6(IIe)	Slight erosion hazard; low fertility
HdC2	Hayden loam, 5 to 9 percent slopes, moderately eroded	11(IIIe)	Moderate erosion hazard; low fertility
HdD2	Hayden loam, 9 to 15 percent slopes, moderately eroded	12(IIIe)	Severe erosion hazard; low fertility
HdE2	Hayden loam, 15 to 20 percent slopes, moderately eroded.	14(IVe)	Severe erosion hazard; low fertility
HsF	Hayden soils, 20 to 50 percent slopes	18(VIIe)	Severe erosion hazard; low fertility
Hu	Huntsville silt loam	2(IIw)	Slight wetness; some flooding
Hv	Huntsville silt loam, channeled	15(Vw)	Severe flooding; wetness
KmA	Kato loam, moderately deep over sand and gravel, 0 to 2 percent slopes.	5(IIs)	Slight droughtiness or slight wetness
KmB	Kato loam, moderately deep over sand and gravel, 2 to 5 percent slopes.	5(IIs)	Slight droughtiness; slight erosion hazard

practices, and expected yields—Continued

Suggested land use and principal accompanying management practices		Expected average crop yields per acre under a high level of management [2]			
Rotations [1] and other land use	Management	Corn	Soybeans	Oats	Hay [3]
		Bushels	*Bushels*	*Bushels*	*Tons*

TABLE 5.—*Suggested rotations, principal management*

Map symbol	Soil	Management group and capability class and subclass	Most serious limitations
Mu	Muck, moderately shallow	8(IIIw)	Ponding; wetness
Mw	Muck, shallow	8(IIIw)	Ponding; wetness
Mx	Mucky peat, deep	8(IIIw)	Ponding; wetness



practices, and expected yields—Continued

Suggested land use and principal accompanying management practices		Expected average crop yields per acre under a high level of management [2]			
Rotations [1] and other land use	Management	Corn	Soybeans	Oats	Hay
		Bushels	*Bushels*	*Bushels*	*Tons*
Continuous row crops	Tile and surface drainage	(4)	(4)		
Pasture	Partial drainage				
Continuous row crops	Tile and surface drainage	(4)	(4)		
Pasture	Partial drainage				
Continuous row crops	Tile and surface drainage	(4)	(4)		
Pasture	Partial drainage				
Continuous row crops	Tile and surface drainage	(4)	(4)		
Pasture	Partial drainage				
Continuous row crops	Tile and surface drainage	(4)	(4)		
Pasture	Partial drainage				
Corn for 3 years, oats, and meadow	Tile drainage, if needed	78	30	55	3. 4
Corn for 3 years, and oats, followed by a legume for green manure.	Tile drainage, if needed	70	28	50	
Corn for 3 years, and oats, followed by a legume for green manure.	Tile and surface drainage	(4)	(4)	(4)	(4)
Same as surrounding soils	Drainage	[4] 65	25	40	2. 5
Same as surrounding soils	Tile and surface drainage, if soil is cultivated	[4] 46	20	40	2. 1
Corn for 3 years, oats, and meadow	Tile or surface drainage, if needed	68	28	50	3. 0
Corn for 3 years, and oats, followed by a legume for green manure.	Tile or surface drainage, if needed	60	25	45	
Same as surrounding soils	Tile and surface drainage, if soil is cultivated	(4)	(4)	(4)	(4)
Corn, oats, and meadow for 2 years	None	15		15	. 7
Pasture	None				
Corn, oats, and meadow for 3 years	Contouring	45		35	2. 0
Corn for 2 years, oats, and meadow for 2 years	Terracing	45		35	2. 0
Pasture or hay	None				2. 0
Permanent hay	None				1. 6
Corn, oats, meadow for 4 years	Stripcropping	35		31	1. 6
Permanent pasture	None				
Permanent pasture	None				
Corn for 3 years, oats, and meadow	None	75	28	55	3. 4
Corn for 3 years, and oats, followed by a legume for green manure.	None	68	26	50	
Corn for 2 years, oats, and meadow for 2 years	Diversions, if needed	73	28	55	3. 4
Corn for 3 years, oats, and meadow	Diversions, if needed, and contouring	73	28	55	3. 4
Corn, oats, and meadow for 2 years	Contouring	69		50	3. 2
[illegible]	Terracing	69		50	3. 2

TABLE 5.—*Suggested rotations, principal management*

Map symbol	Soil	Management group and capability class and subclass	Most serious limitations
WdB	Waukegan loam, deep over sand and gravel, 2 to 5 percent slopes.	6(IIe)	Slight erosion hazard
WdC2	Waukegan loam, deep over sand and gravel, 5 to 9 percent slopes, moderately eroded.	11(IIIe)	Moderate erosion hazard
Wy	Webster silty clay loam	3(IIw)	Wetness
Wz	Webster silty clay loam, calcareous variant	3(IIw)	Wetness; low fertility

[1] The most intensive use of row crops consistent with good soil conservation is set forth in the suggested rotations, which must be accompanied by the principal practices listed. Grain sorghum or soybeans may be substituted for corn; other small grains may be substituted for oats.

[2] See text for what is meant by "a high level of management" and for the basis on which yields were estimated.

[3] Hay yields based on first-year stands and three cuttings during

Class I soils are those that have the widest range of use and the least risk of damage. They are level or nearly level, productive, well drained, and easy to work. They can be cultivated with almost no risk of erosion and will remain productive if managed with normal care.

Class II soils can be cultivated regularly, but they do not have quite so wide a range of suitability as class I soils. Some class II soils are gently sloping and, consequently, need moderate care to prevent erosion. Other soils in class II may be slightly droughty, slightly wet, or somewhat limited in depth.

Class III soils can be cropped regularly, but they have a narrower range of use than class II soils, and they need even more careful management.

In class IV are soils that should be cultivated only occasionally or only under very careful management.

In classes V, VI, and VII are soils that normally should

Management group 1.—Level and nearly level soils that can be cultivated without special management practices.

Class II.—Soils that have some limitations that reduce the choice of plants or require moderate conservation practices.

Subclass IIw.—Wet soils that generally can be drained satisfactorily with tile.

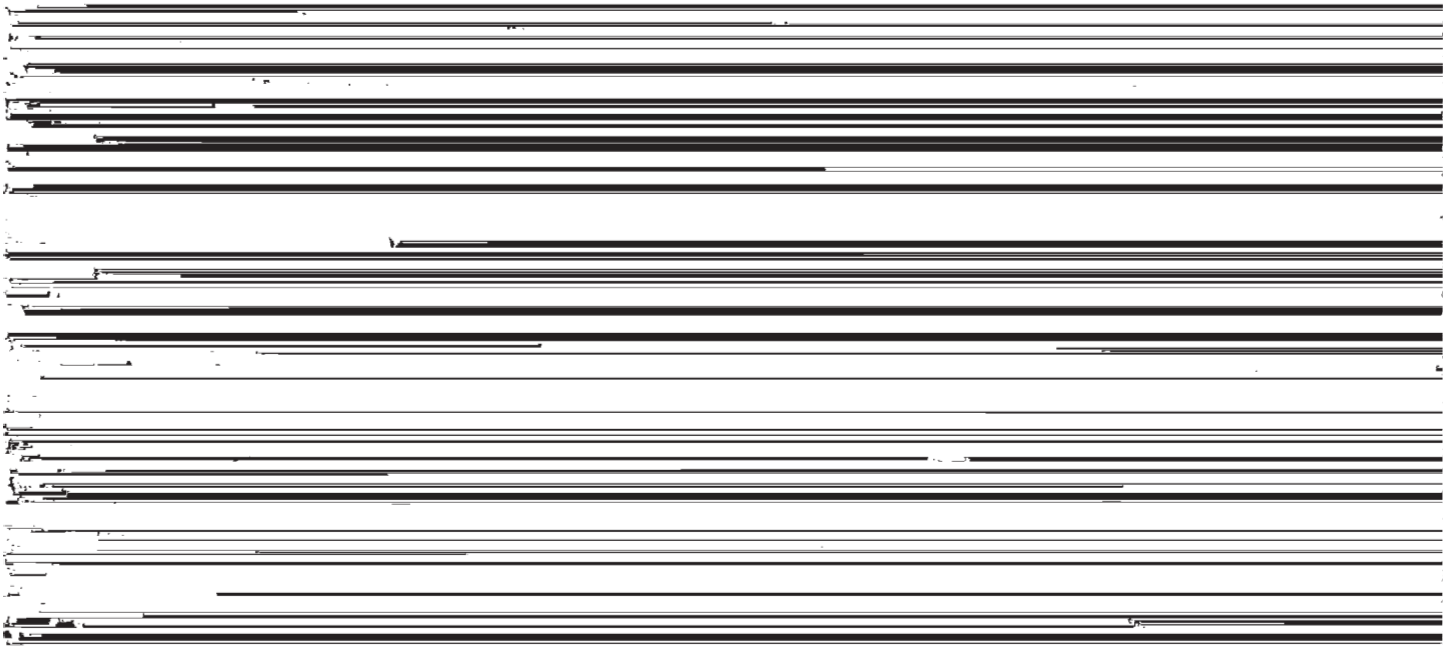
Management group 2.—Poorly drained and imperfectly drained soils of the bottom lands.

Management group 3.—Level to nearly level, dark-colored soils that are poorly drained and imperfectly drained.

Management group 4.—Poorly drained, "high-lime" soils.

Subclass IIs.—Slightly droughty soils.

Management group 5.—Nearly level to undu-



practices, and expected yields—Continued

Suggested land use and principal accompanying management practices		Expected average crop yields per acre under a high level of management [2]			
Rotations [1] and other land use	Management	Corn	Soybeans	Oats	Hay [3]
		Bushels	*Bushels*	*Bushels*	*Tons*
Corn for 2 years, oats, and meadow for 2 years	None	62	25	52	2.6
Corn for 3 years, oats, and meadow	Contouring	62	25	52	2.6
Corn, oats, and meadow for 2 years	Contouring	50		42	2.2
Corn for 3 years, oats, and meadow	Terracing	50		42	2.2
Corn for 3 years, oats, and meadow	Tile drainage	76	29	55	3.2
Corn for 3 years, and oats, followed by a legume for green manure.	Tile drainage	68	27	50	
Corn for 3 years, oats, and meadow	Tile drainage	69	24	50	3.0
Corn for 3 years, and oats, followed by a legume for green manure.	Tile drainage	61	22	45	

the year. If soil is suited to alfalfa, hay crop is assumed to consist of alfalfa and bromegrass.

[4] Yields for these soils are highly variable because complete drainage is seldom obtained. They are pothole soils, and they pond after heavy rains unless excellent surface drainage has been installed. The soils are potentially productive, however, except for the Orio soils, and average yields of 45 to 75 bushels can be expected if flooding is controlled.

Management group 12.—Rolling, well-drained [redacted] Subclass VIIe.—Soils that are steep, or severely

high yields can be obtained. Nitrogen is needed for corn that does not follow a legume crop. The amounts of lime and fertilizer to be applied should be based on the results of soil tests.

Although these soils can be farmed without artificial drainage, some of them have a slight drainage problem in years of high rainfall. In these years, tile drains help to maintain yields.

Erosion is not ordinarily a problem. Nevertheless, under intensive row cropping, it may be best to contour the long slopes.

If corn is to be planted in spring, these soils are usually plowed the preceding fall. This subjects the soils to wind erosion. Leaving a plowed surface rough and leaving strips of vegetation unplowed help to reduce wind erosion.

MANAGEMENT GROUP 2(IIw)

Management group 2 consists of fertile bottom-land soils that are poorly and imperfectly drained. These soils are suitable for frequent row cropping. The soils are—

Colo silt loam.
Colo silty clay loam.
Huntsville silt loam.
Webster silty clay loam.
Webster silty clay loam, calcareous variant.

These level to nearly level soils are occasionally flooded, but the hazard varies from area to area. The soils hold a large quantity of water available for plants but have

These soils are wet and generally need artificial drainage. They have a fairly large to large capacity for holding water that plants can use. They have a medium to large supply of plant nutrients and organic matter. Some of these soils are slightly acid; some are slightly calcareous; the Dundas soil is medium acid to strongly acid. The soils are fairly easy to work except after a long rainy period.

Use and management.—Because of the smooth surface, high fertility, good response to fertilizer, and good water-holding capacity, these soils are well suited to intensive use if artificially drained. Tile work well. The Okoboji variant needs surface drainage in some places. Information on drainage can be obtained from the local representative of the Soil Conservation Service or the County Extension Director, or it can be found in the Iowa Drainage Guide (*6*).

If these soils have been adequately drained, they are suited to corn, soybeans, oats, legumes, grasses, and most other farm crops. A suggested rotation is 3 years of row crops, 1 year of small grain, and a year of meadow; or 3 years of row crops and 1 year of a small grain with a legume interplanted for green manure. Undrained areas not used for grain are ordinarily suitable for birdsfoot trefoil and bluegrass.

These soils are usually plowed in fall because wetness may delay work in spring. Although fall plowing sub-

have a large capacity for holding water that plants can use.

Use and management.—These soils are suited to corn, soybeans, oats, legumes, grasses, and most other farm crops. A suitable rotation is 3 years of row crops and a year of small grain followed by meadow, or 3 years of row crops and a year of oats with a legume interplanted for green manure. Small areas of these soils are cropped along with the surrounding soils.

Unless the soils are heavily fertilized, corn yields are commonly 30 bushels per acre lower than on the adjacent soils. Large amounts of phosphate and potash fertilizer are needed if high yields are to be obtained under intensive cropping. Nitrogen is especially needed for corn that does not follow a good legume crop. Legumes respond well to phosphate fertilizers. The amount of fertilizer applied should be based on soil tests. No lime should be applied.

Because the soils do not contain enough iron for soy-

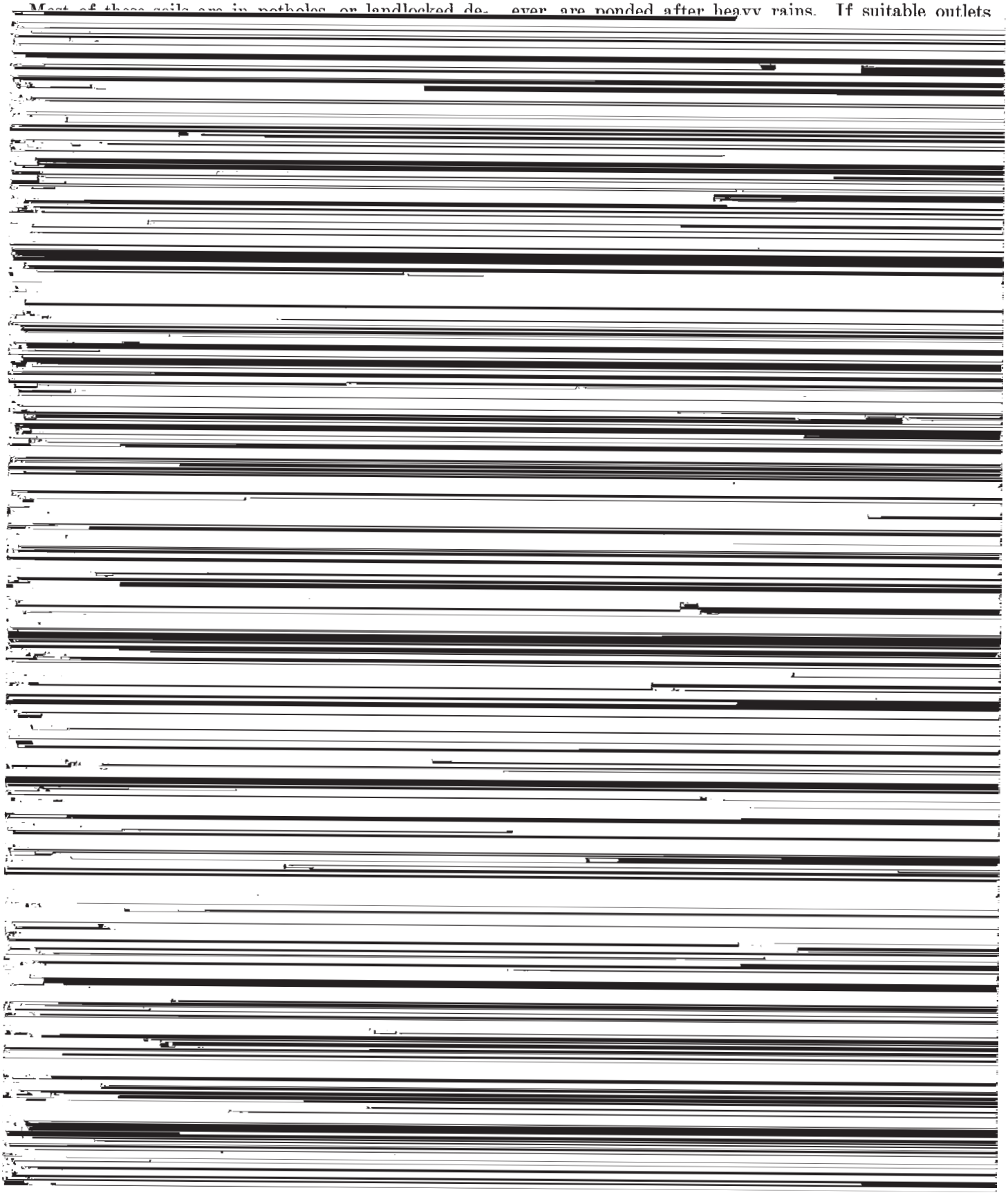
On the sandier soils of this group, wind erosion is sometimes severe and blowing sand may damage young plants. Crop residues left on the surface help to reduce damage by wind erosion. These soils are easy to work. They do not need artificial drainage.

MANAGEMENT GROUP 6(IIe)

Management group 6 consists of dark colored and moderately dark colored, undulating soils that are well drained and imperfectly drained. These soils are very productive. They are—

Clarion loam, 2 to 5 percent slopes.
Clarion loam, 2 to 5 percent slopes, moderately eroded.
Clarion loam, thin solum, 2 to 5 percent slopes.
Hayden loam, 2 to 5 percent slopes.
Kato loam, deep over sand and gravel, 2 to 5 percent slopes.
Lester loam, 2 to 5 percent slopes.
Terril loam, 2 to 5 percent slopes.
Truman silt loam, 2 to 5 percent slopes.
Waukegan loam, deep over sand and gravel, 2 to 5 percent

Most of these soils are in potholes, or landlocked de- ever, are ponded after heavy rains. If suitable outlets



sisting of a year of a row crop, a year of small grain, and 2 years of meadow is suggested. With terraces, a rotation made up of 2 years of row crops, a year of small grain, and a year of meadow can be used.

For best yields, apply organic matter in the form of barnyard manure or crop residues. Commercial fertilizer and lime are also needed. The amounts to apply should be based on soil tests. Heavy applications of fertilizer are not economical, because the soils are droughty. The response to light applications is good.

These soils are moderately susceptible to erosion. They should be contoured and terraced where feasible. Maintaining terraces is difficult if there is loose sand, but

MANAGEMENT GROUP 12 (IIIe)

Management group 12 consists of rolling, well-drained soils on slopes that are mostly short and irregular. The soils in this group are moderately productive. They are—

Clarion loam, 9 to 15 percent slopes, moderately eroded.
Hayden loam, 9 to 15 percent slopes, moderately eroded.
Lester loam, 9 to 15 percent slopes, moderately eroded.
Storden loam, 9 to 15 percent slopes, moderately eroded.
Truman silt loam, 9 to 15 percent slopes, moderately eroded.

These are light colored to moderately dark colored soils. Except for the Storden loam, they are medium acid. They hold a large quantity of water available for

gested is a year of a row crop, a year of small grain, and 2 years of meadow. This rotation is suitable for the Sogn soil without erosion control practices. If the soils are terraced, a suitable rotation is a year of a row crop, a year of small grain, and a year of meadow.

Unless these soils are contoured and terraced, they erode readily if planted to row crops. Sometimes wind erosion is severe, and blowing sand may damage young plants on the sandy loams. Crop residues left on the surface help to reduce the damage.

These soils respond well to light applications of fertilizer. Apply lime and fertilizer according to needs shown by soil tests. Heavy fertilization is not economical, because the soils are droughty.

MANAGEMENT GROUP 14(IVe)

Management group 14 consists of well-drained, hilly soils that are moderately productive. The soils in this group are—

Clarion loam, 15 to 20 percent slopes, moderately eroded.
Hayden loam, 15 to 20 percent slopes, moderately eroded.

drainage is provided, and stream channels are straightened, they are seldom suitable for cultivation. They are probably best used for pasture. In most areas it is generally worth while to improve pastures. The amounts of fertilizer to apply should be based on soil tests. Canarygrass is suitable where silt is deposited and where water is apt to stand for several days. Birdsfoot trefoil is suitable for all areas except those that are timbered, those on which water stands for long periods, and those where siltation is heavy. A mixture of bluegrass and birdsfoot trefoil provides excellent pasture and usually can be established without great difficulty.

MANAGEMENT GROUP 16(VIe)

Management group 16 consists of steep soils that are suitable for pasture or trees. These soils are low in productivity. They are—

Clarion loam, 20 to 30 percent slopes, moderately eroded.
Lester soils, 20 to 30 percent slopes.
Storden loam, 20 to 30 percent slopes, severely eroded.

All of these soils erode readily if they are cultivated.

difficult because of the sandy texture. Tillage practices that leave crop residues on the surface and the addition of strawy manure after seeding will help protect young plants from damage by blowing sand and will temporarily increase the moisture-supplying capacity. Grazing should be controlled, to help maintain good stands of pasture plants.

Phosphate fertilizer will be needed in most areas. The application of fertilizer or lime should be based on soil tests.

Alternative uses for these soils are timber and wildlife.

MANAGEMENT GROUP 18(VIIe)

Management group 18 consists of hilly and steep upland soils that are subject to severe erosion if unprotected. They are suitable for use as woodland and for limited use as pasture. These soils are low in productivity. They are—

Clarion loam, 30 to 50 percent slopes.
Hayden soils, 20 to 50 percent slopes.
Lester soils, 30 to 50 percent slopes.
Storden loam, 30 to 50 percent slopes, severely eroded.

All these soils are subject to erosion. They are low in nitrogen, in available phosphorus, and in organic matter.

Use and management.—The use of these soils is limited by their steep slopes, sandy nature, or eroded condition. They are not suitable for grain but are suitable for alfalfa, bromegrass, or birdsfoot trefoil. They are best for permanent pasture or trees. Renovating pastures by using ordinary farm equipment is almost im-

move downward in the soil and are partly removed by drainage water.

Soil morphology in Humboldt County is expressed by both faint and prominent horizons. The Storden, Clarion, Nicollet, Webster, and Glencoe soils have faint horizons. The Rolfe, Orio, Ames, and Cullo soils have prominent horizons. Soils that have intermediate horizonation are the Hayden, Dundas, and LeSueur. Some soils have a marked difference between the texture of the solum and the texture of the underlying D horizon. These soils are the Farrar, Waukegan, Kato, Marshan, and Dickinson, bench position.

Horizon differentiation in the soils of Humboldt County is the result of one or more of the following processes: (1) Accumulation of organic matter; (2) leaching of calcium carbonates and bases; (3) formation and translocation of silicate clay minerals; (4) reduction and transfer of iron; and (5) a process not entirely understood but considered to be accumulation of calcium carbonates. Most of the soils have been affected by two or more of these processes.

Most soils in Humboldt County have some organic matter accumulation, which forms an A_1 horizon. The A_1 horizons in the organic soils of Humboldt County are 20 to 60 percent organic matter. Most of the soils that developed under prairie vegetation in Humboldt County are relatively high in organic matter, compared with soils that developed under prairie in other regions. Some of the mineral soils that are high in organic matter (dominantly humus) are the Glencoe, Nicollet, Webster, Oko-

Gleying, or the process of reduction and transfer of iron (*17*), is evident in the poorly drained and very poorly drained soils. The Glencoe, Webster, Marshan, Colo, Wabash, Harpster, and Dundas soils have gleyed (B_g) horizons. The B_g horizons are gray, which indicates the reduction and loss of iron. In some soils, there are reddish-brown iron concretions. The C horizons ordinarily are not gleyed, and the boundary is gradual between the gleyed B horizon and the C horizon.

Laboratory data

Laboratory data for profiles of 6 soils are presented in tables 6, 7, and 8.

Factors of soil formation

soils formed. The Dickinson and Lamont soils formed where the fine sandy material is dominantly more than 10 feet thick.

Vegetation.—Most of the soils of Humboldt County formed under prairie grasses; some formed under forests composed chiefly of oak, maple, ash, and elm; and some under transitional prairie-forest vegetation. The vegetation in potholes and other depressions was sedges, cattails, rushes, and other similar plants. These plants may not have been the dominant ones all the time since the last glaciation. Lane (*7*) studied the pollen in soil taken from a peat bog in the northern part of Iowa. These studies revealed that pollen, from the base of the soils upward, was that of (1) spruce, (2) fir with spruce and birch, (3) birch with fir and oak, (4) oak and

The thickness and color of the A horizon of the Storden, Clarion, and Nicollet soils are directly related to topography. The A horizon becomes thicker and darker Storden to Clarion to Nicollet. The Webster and Glencoe soils are also a part of the topographic sequence. The Webster soils are nearly level and the Glencoe soils are

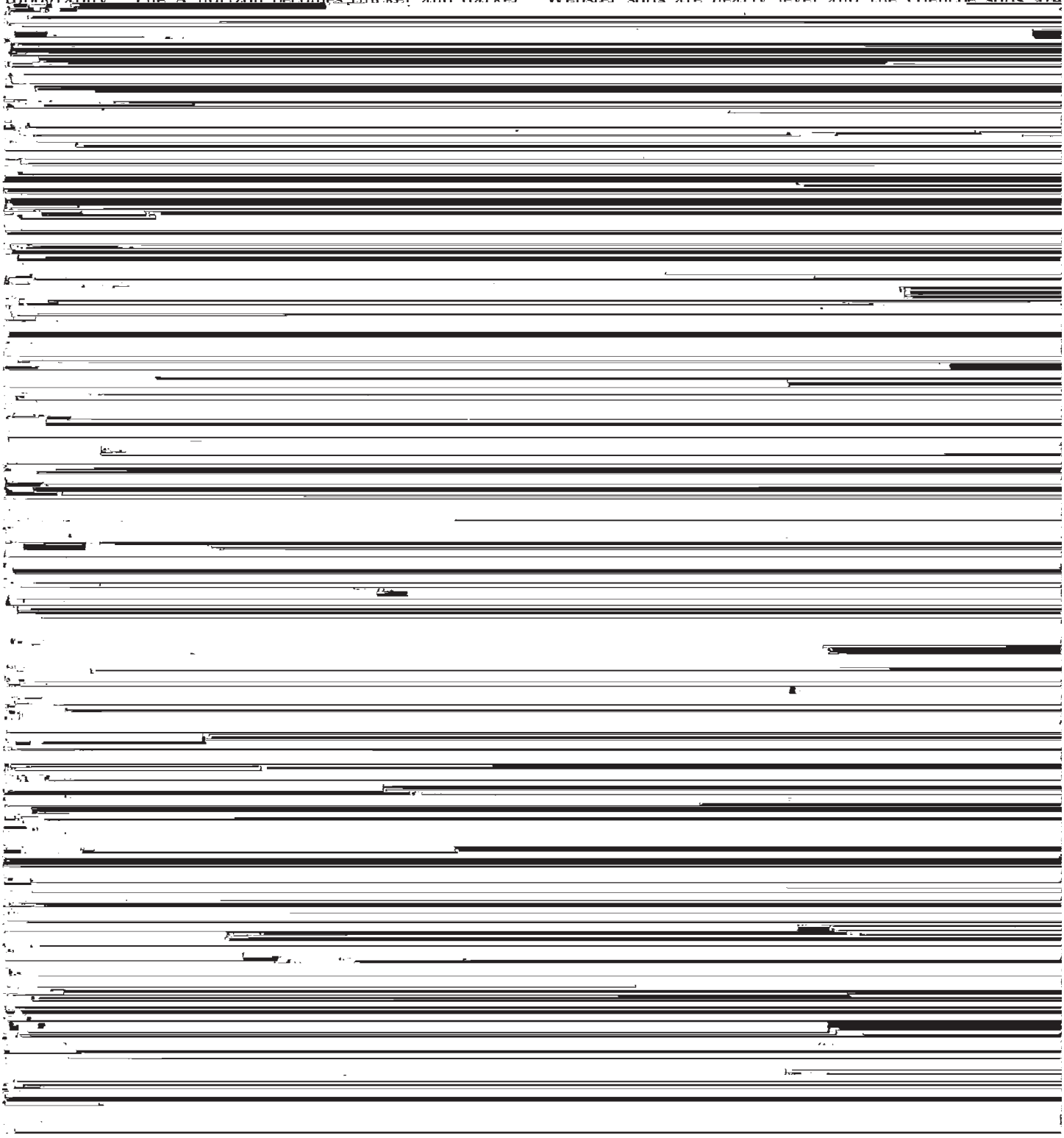


TABLE 7.—*Partial data on physical and chemical properties, Dickinson fine sandy loam, Humboldt County, Iowa* [1]

Horizon designation	Depth	pH	Size of particles (in millimeters)							Exchangeable cations (meq./100 gm. of soil)				Free Fe	N
			Sand					Clay	Silt	H	Ca	Mg	K		
			2 to 1	1 to 0.5	0.5 to 0.25	0.25 to 0.1	0.1 to 0.05	<0.002	0.002 to 0.05						
	Inches		*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*					*Percent*	*Percent*
A_1	0 to 10	7.1	0.4	9.4	21.2	30.1	8.5	12.5	17.8	0.3	9.9	2.2	0.19	0.35	0.14
B_1	10 to 15	6.5	.5	9.8	21.6	29.7	8.2	14.4	15.7	1.1	7.4	2.2	.16	.42	.10
B_2	15 to 18	5.9	.4	8.5	21.3	34.3	10.8	13.0	11.5	1.4	5.6	1.6	.17	.40	.06
B_3	18 to 30	6.1	.4	6.6	19.7	42.5	14.0	11.4	5.3	.7	4.7	1.7	.19	.44	.03
C_1	30 to 40	6.2	.8	11.9	26.7	41.6	9.3	6.0	3.6	1.0	2.5	1.2	.16	.26	.01
C_2	40 to 50	5.6	.9	10.6	25.8	43.3	10.0	5.5	4.0	.8	2.4	1.0	.15	.24	.00
C_3	50 to 60	5.9	.6	7.7	21.6	48.4	13.9	4.0	4.2	.8	2.3	1.0	.17	.23	.00

[1] See PHYSICAL AND CHEMICAL PROPERTIES OF SOME IOWA SOIL PROFILES WITH CLAY-IRON BANDS (*2*).

TABLE 8.—*Laboratory data for Webster clay loam, Humboldt County, Iowa* [1]

Horizon designation	Depth	Particle size (in millimeters)			Total N [2]	Total organic matter	Exchangeable cations (meq./100 gm. of soil)			
		Sand (all sizes)	Silt 0.002 to 0.05	Clay <0.002			H	Ca	Mg	K
	Inches	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*				
A	0 to 8	26.7	39.1	34.2	0.404	7.1	2.9	32.2	7.7	0.3
	8 to 13	27.8	38.5	33.7	.387	6.4	3.5	29.8	7.9	.4
	13 to 17	29.6	35.6	34.8	.207	3.3	4.0	22.9	7.1	.4
B	17 to 21	33.0	33.0	34.0	.150	1.9	4.0	20.3	6.0	.3
	21 to 26	38.0	30.3	31.7	.109	.9	3.0	19.0	6.4	.3
C_1	26 to 31	40.1	31.8	28.1	.082	.5	.4	26.8	5.9	.3
C_2	31 to 37	40.2	35.6	24.2	.071	.3	.0	28.5	4.6	.2
	37 to 43	36.7	39.3	24.0	[3]	.1	.0	28.7	4.6	.3
	43 to 50	36.2	39.2	24.6	[3]	.1	.0	29.2	4.5	.3
	50 to 60	39.9	35.8	24.3	[3]	.1	.0	27.2	4.7	.2

[1] See UNDERSTANDING IOWA SOILS (*18*).

[2] CARDOSO, J. SEQUENCE RELATIONSHIPS OF CLARION, LESTER, AND HAYDEN SOIL CATENAS. Unpublished Ph. D. thesis. Iowa State University Library, Ames. 1957.

[3] Not determined.

Classification of Soils

For the purpose of comparing the soils of Humboldt County with soils elsewhere, soil series with certain fundamental characteristics in common are grouped together (*16*).

The great soil groups of Humboldt County are Brunizems, Wiesenbodens, Planosols, Gray-Brown Podzolic soils, Bog soils, Regosols, and Lithosols. The soil series are classified into these great soil groups as follows:

Great soil group	*Series*
Brunizems	Ankeny.
	Clarion.
	Dickinson.
	Farrar.
	Garmore.
	Kato.
	Lakeville.
	Nicollet.
	Truman.
	Waukegan.
Brunizems that intergrade to Alluvial soils.	Copas.
	Huntsville.
	Okoboji, imperfectly drained variant.
	Plattville.
	Terril.
Wiesenbodens	Harpster.
	Marshan.
	Wabash.
	Wacousta.
	Webster.
Wiesenbodens that intergrade to Alluvial soils.	Colo.
	Glencoe.
	Okoboji.
Planosols	Ames.
	Cullo.
	Orio.

have thick, black to very dark gray A horizons, generally 15 to 20 inches thick; slightly developed B horizons, generally dark colored in the upper part; and gleyed horizons, commonly light olive gray and strongly mottled, below the middle or lower B horizons. These soils in Humboldt County are young soils that do not have as strongly expressed characteristics as Wiesenbodens elsewhere. The Wiesenbodens in Humboldt County are the Harpster, Marshan, Wabash, Wacousta, and Webster soils. The Colo, Glencoe, and Okoboji soils developed from alluvial material or reworked glacial material. They are classified as Wiesenbodens that intergrade to the Alluvial group.

Planosols have one horizon that is much higher in clay, more compact, or more strongly cemented than the horizon immediately above or below it. In Humboldt County, they develop under poor natural drainage and have grayish, leached A_2 horizons and strongly developed, gleyed, genetic-claypan B horizons. The claypan is plastic and only slightly pervious.

The Planosols in Humboldt County are the Ames, Cullo, Orio, and Rolfe soils. The Dundas soils are Planosols that intergrade to Wiesenbodens.

In Humboldt County, Gray-Brown Podzolic soils develop under forest vegetation. They have thin, light-colored A_1 horizons, brownish to grayish A_2 horizons, and brownish B horizons that have an accumulation of clay. They are acid throughout. Gray-Brown Podzolic soils in Humboldt County are the Hayden and Lamont soils. Lester and LeSueur soils are Gray-Brown Podzolic soils that intergrade to Brunizems.

Bog soils have mucky or peaty surface horizons and are underlain by gray mineral soil. They develop chiefly un-

from 3 to 6 inches in thickness. It may be loam to silt loam in texture and dark gray (10YR 4/1)[8] to very dark gray (10YR 3/1) in color. The A_2 horizon ranges from 10 to 15 inches in thickness, from light silt loam to light loam in texture, and from dark gray (10YR 4/1) to gray (10YR 6/1) in color. The B horizon ranges from heavy clay loam or gritty silty clay loam to clay.

Although ranges overlap, the Ames soils generally have a lighter colored A_1 horizon, a thicker A_2 horizon, and a finer textured B horizon than Dundas soils.

Ames loam (SW¼NE¼ sec. 4, T. 92 N., R. 28 W.):

A_p 0 to 5 inches, very dark gray to dark gray (10YR 3.5/1), dark-gray (10YR 4/1, dry), medium silt loam; moderate, thin, platy structure; light-gray (10YR 6/1, dry) coatings on plates; friable when moist; medium acid; clear boundary.

A_{21} 5 to 9 inches, dark-gray (10YR 4/1), gray (10YR 5/1, dry), medium loam; moderate to strong, thin, platy structure; medium acid; friable when moist; clear boundary.

The Ankeny soils are better drained than the Terril soils and are coarser textured throughout. They have a thicker A horizon than the Dickinson soils.

Ankeny sandy loam (NE¼NW¼ sec. 6, T. 92 N., R. 30 W.):

A_{1p} 0 to 6 inches, very dark brown (10YR 2/2) sandy loam; weak, fine, granular structure; very friable when moist.

A_{12} 6 to 26 inches, very dark brown (10YR 2/2) sandy loam; weak, fine, granular structure; very friable when moist.

B_1 26 to 36 inches, very dark grayish-brown (10YR 3/2) light sandy clay loam; very weak, medium, subangular blocky structure; friable when moist.

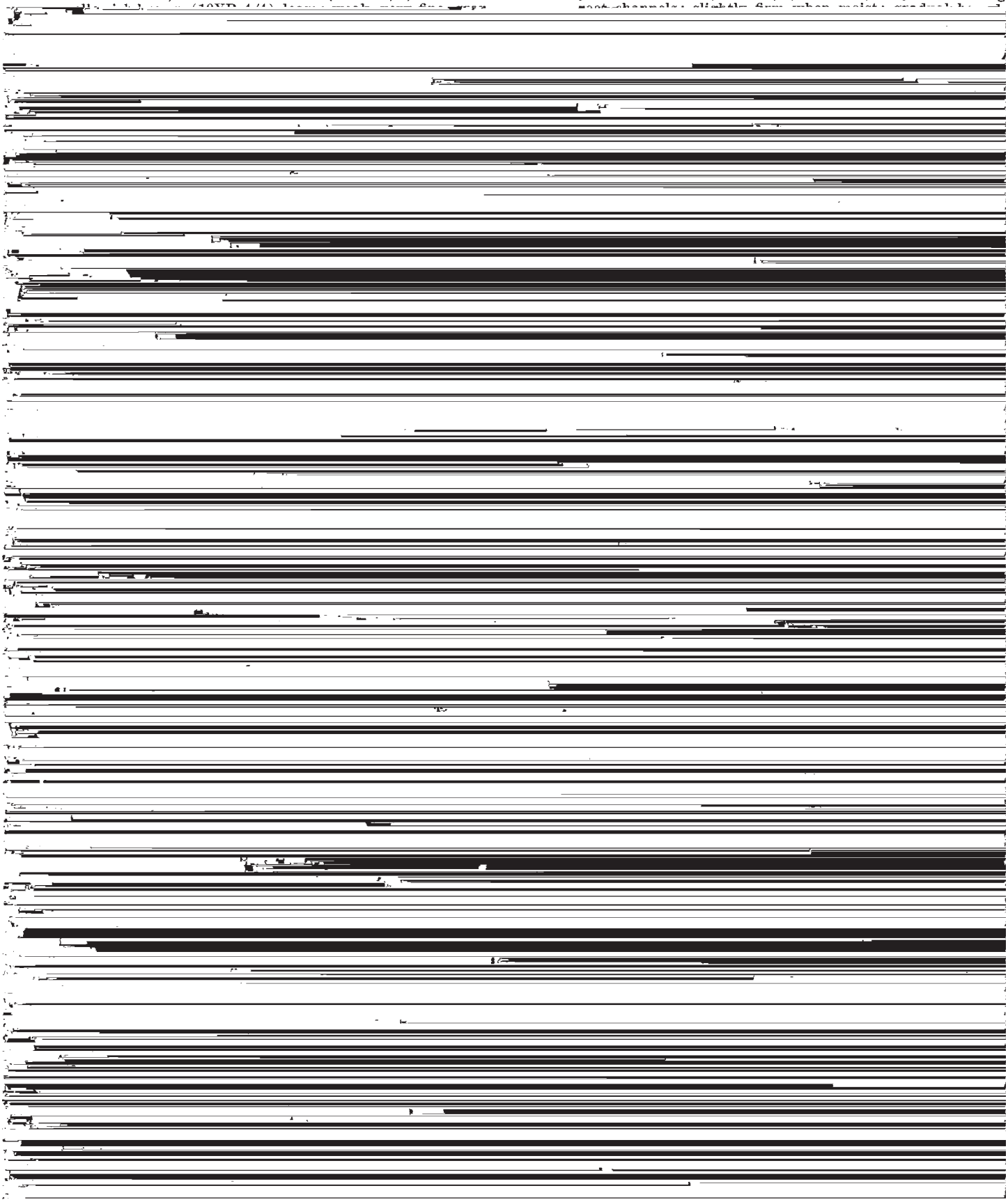
B_2 36 to 45 inches, very dark grayish-brown (10YR 3/2) light clay loam; very weak, medium, blocky structure; friable when moist.

C_1 45 to 50 inches, dark grayish-brown (10YR 4/2) sandy loam; massive; very friable when moist.

CLARION SERIES

The soils of the Clarion series are well-drained, moder-

B 9 to 15 inches, mixed dark-brown (10YR 3/3) and dark [illegible] yellowish-brown (10YR 5/4) mottles; clay films along [illegible]



texture, and from very dark gray (5Y 3/1) to olive-gray (5Y 4/2) or dark grayish-brown (2.5Y 4.2) in color. In this horizon there are discontinuous clay films along the vertical cleavage planes.

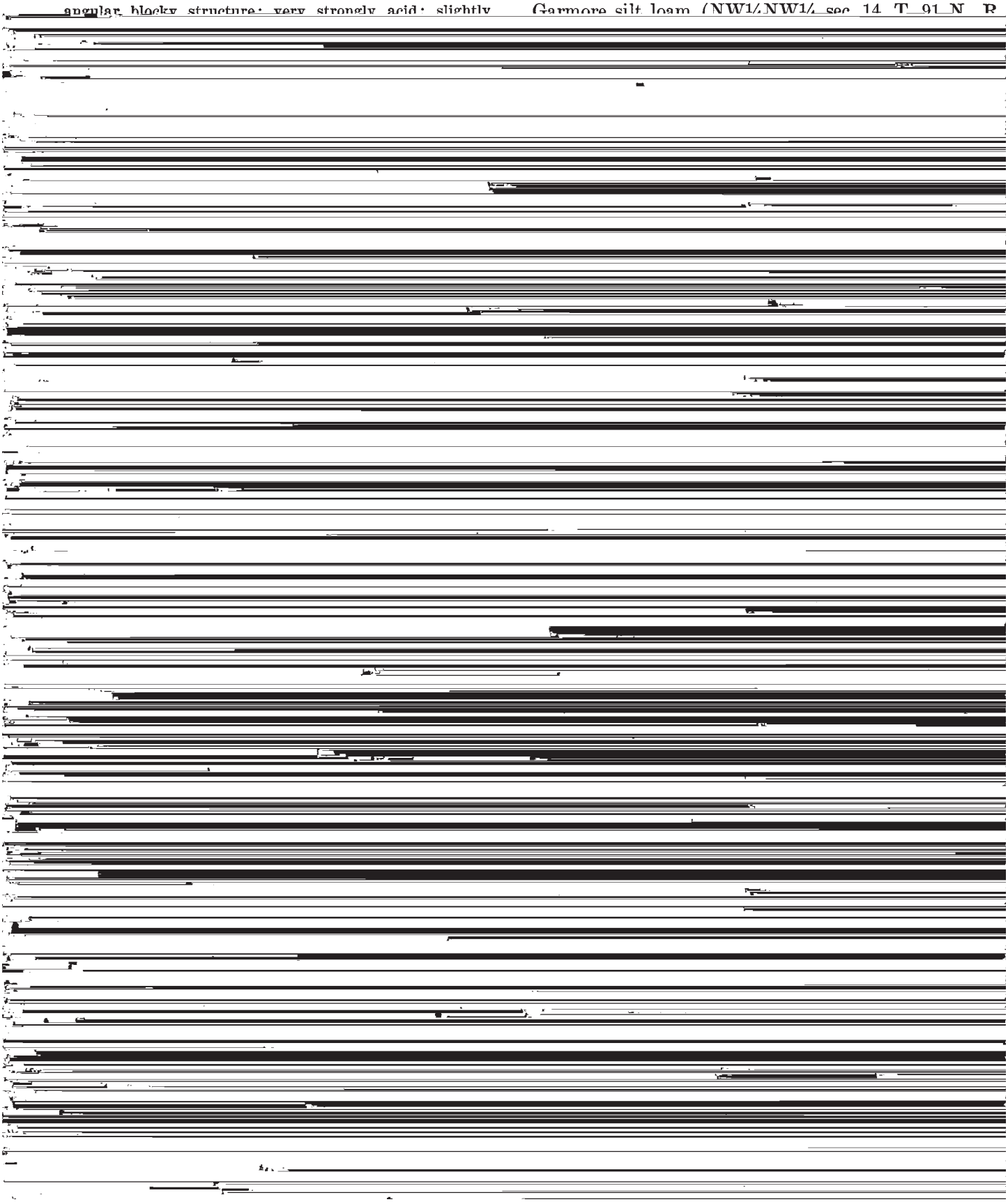
The C_g horizon is friable, stratified, glacial drift; it contains layers of silt, coherent sand, and loam and nor-

Dickinson fine sandy loam (300 feet south of NW¼-NW¼ sec. 15, T. 93 N., R. 30 W.):

A_1 0 to 10 inches, very dark gray (10YR 3/1) fine sandy loam; weak, fine, granular structure; very friable when moist.

B_1 10 to 15 inches, mixed very dark grayish-brown (10YR 3/2) and very dark brown (10YR 2/2) sandy loam; very

angular blocky structure; very strongly acid; slightly Garmore silt loam (NW¼NW¼ sec. 14, T. 91 N., R.



The Glencoe soils have a thicker A horizon and a finer textured B horizon than the Webster soils. They are finer textured throughout than the Okoboji soils, which occupy similar positions.

Laboratory data for the following profile is presented in table 6, p. 47.

Glencoe silty clay loam (100 yards south and 90 yards east of the NW corner of NW¼NW¼ sec. 32, T. 92 N., R. 27 W., Lake Township):

A_{1p} 0 to 7 inches, black (5Y 2/1) silty clay loam; moderate, medium, granular structure; slightly firm when moist.

A_{12} 7 to 11 inches, black (5Y 2/1) silty clay loam; weak, fine, subangular blocky structure; slightly firm when moist.

A_{13} 11 to 14 inches, black (5Y 2/1) light silty clay loam; weak, very thin, platy structure; slightly firm when moist.

A_{14} 14 to 17 inches, black (5Y 2/1) light silty clay loam; weak, very thin, platy structure; slightly firm when moist.

A_3 17 to 20 inches, black (5Y 2/1) silty clay loam; weak, very thin, platy structure; slightly firm when moist.

B_{1g} 20 to 23 inches, black (5Y 2/1, 2/2) heavy silty clay loam; moderate, very fine, subangular blocky structure; firm when moist.

B_{21g} 23 to 26 inches, black (5Y 2/1, 2/2) light silty clay; moderate, very fine, subangular blocky structure; firm when moist.

B_{22g} 26 to 30 inches, black (5Y 2/1, 2/2, moist) light silty clay; moderate, very fine, subangular blocky structure; firm when moist.

B_{23g} 30 to 34 inches, black (5Y 2/1, 2/2) light silty clay; moderate, very fine, subangular blocky structure; firm when moist.

B_{31g} 34 to 38 inches, black (5Y 2/1) to very dark gray (5Y 3/1) heavy silty clay loam; weak, very fine, subangular blocky structure; firm when moist.

B_{32g} 38 to 44 inches, black (5Y 2/1) to very dark gray (5Y 3/1) heavy silty clay loam; weak, very fine, subangular blocky structure; firm when moist.

B_{33g} 44 to 49 inches, very dark gray (5Y 3/1) heavy silty clay loam; weak, very fine, subangular blocky structure with vertical cleavage planes; firm when moist.

C_{2g} 49 to 56 inches, gray (5Y 5/1) to light-gray (5Y 6/1) heavy silt loam; massive; yellowish-brown (10YR 5/6, 5/8) iron mottles; calcareous; occasional snail shells;

The A horizon, 8 to 14 inches thick, is a loam to light clay loam or silty clay loam. The color of this layer varies from dark gray (5Y 4/1) to black (5Y 2/1), but grays predominate. The B horizon ranges from a light clay loam to light silty clay loam. The surface horizon is grayer and less fine textured than the corresponding layer in Webster silty clay loam, calcareous variant. Harpster loams are more poorly drained than Harpster silt loams.

Harpster loam (SE¼SE¼ sec. 4, T. 92 N., R. 28 W.):

A_{1ca} 0 to 6 inches, mixed dark-gray (10YR 4/1) and very dark gray (10YR 3/1) heavy loam; moderate, medium, granular structure; calcareous; snail-shell fragments common on surface; friable when moist.

A_{3ca} 6 to 9 inches, mixed dark-gray (10YR 4/1) and very dark gray (10YR 3/1) heavy loam; weak, medium, granular structure; calcareous; friable when moist.

B_{g1ca} 9 to 18 inches, mixed dark-gray (10YR 4/1) and very dark grayish-brown (2.5Y 3/2) light clay loam; weak, fine and medium, subangular blocky structure; calcareous; slightly firm when moist.

B_{g2ca} 18 to 22 inches, dark-gray (10YR 4/1) light clay loam; very dark grayish-brown (2.5Y 3/2) and dark grayish-brown (10YR 4/2) mottles; very weak, fine, subangular blocky structure; calcareous; slightly firm when moist.

C 22 to 60 inches, mottled grayish-brown (2.5Y 5/2), very dark grayish-brown (2.5Y 3/2), and olive-gray (5Y 5/2) loam; massive; calcareous; friable when moist.

Harpster loams, sand and gravel substratum.—These soils developed from alluvium or outwash materials on stream terraces and on beaches around former lakes. The slopes are ½ to 1½ percent.

The A_1 horizon varies from dark gray (5Y 4/1) to black (10YR 2/1), but grays predominate. The thickness of the A horizon is 7 to 14 inches, and the texture is light loam to heavy loam and, in a very few areas, sandy loam. The B and C horizons range from loam to light clay loam. Below depths of 30 to 50 inches, there is sand, sandy loam, or gravel.

Harpster loam, sand and gravel substratum (SW¼SW¼ sec. 1, T. 93 N., R. 30 W.):

The A_1 horizon ranges from 7 to 16 inches in thickness,

B_{22} 19 to 25 inches, dark-brown (10YR 3/2.5), dark-brown (10YR 3.5/3) when crushed, medium clay loam; weak

plain. They are underlain by an unconforming substratum (D horizon) of sand and gravel. The soils are acid throughout the solum and have moderate permeability. The principal native vegetation was prairie grasses.

Kato loams, deep over sand and gravel.—These soils are underlain by sand and gravel below a depth of 36 inches. The A horizon ranges from 10 to 20 inches in

Kato loam, moderately deep over sand and gravel, (SE¼NE¼ sec. 15, T. 93 N., R. 27 W.):

A_1 0 to 15 inches, black (10YR 2/1) loam; weak, fine, granular structure; friable when moist.

B_2 15 to 25 inches, very dark grayish-brown (10YR 3/2) light clay loam; weak, fine, subangular blocky structure; few, fine, faint, dark-brown (10YR 3/3) and very dark

B_2 20 to 30 inches, dark-brown (10YR 3/3) light sandy clay loam; weak, fine to medium, subangular blocky structure; few, discontinuous, very dark grayish-brown (10YR 3/2) clay films; medium acid; friable when moist; hard when dry; gradual boundary.

B_3 30 to 36 inches, dark yellowish-brown (10YR 4/4) sandy loam; massive; some dark-brown (7.5YR 3/3) ped coatings; medium acid; friable when moist; hard when dry; gradual boundary.

C 36 to 50 inches, dark-brown (10YR 4/3) loamy sand; single grain; slightly acid; very friable to loose when moist.

LESTER SERIES

The Lester series consists of well-drained soils that developed from friable, calcareous, loam till of Late Wisconsin age. These soils are classified as Gray-Brown Podzolic soils that intergrade to Brunizems. They occur in the more hilly areas along the major streams. The slopes range from 2 to 50 percent and are concave and convex. The soils are acid throughout the solum and are leached of carbonates to depths of 40 to 60 inches. They are moderately permeable. The native vegetation was mixed grass and trees. Presumably, the trees recently encroached on the prairie.

The A_1 horizon is as much as 9 inches thick in the nearly level areas. It decreases in thickness with increase in gradient. The texture of the A_1 horizon ranges from light to heavy loam. The incipient A_2 horizon is 2 to 5 inches thick. The B horizon ranges from heavy loam to light clay loam.

The Lester soils differ from the Clarion soils in having a weak A_2 horizon, a lighter colored A_1 horizon, and slightly finer textured B horizon.

Lester loam (SW¼NW¼ sec. 13, T. 93 N., R. 28 W.):

A_1 0 to 6 inches, very dark grayish-brown (10YR 3/2) loam; weak, medium, granular structure; friable when moist.

A_2 6 to 9 inches, dark grayish-brown (10YR 4/2) loam; weak, medium, platy breaking to granular structure; friable when moist.

B_1 9 to 14 inches, dark-brown (10YR 3/3) heavy loam; weak, fine to medium, subangular blocky structure; friable when moist.

B_2 14 to 27 inches, dark-brown (10YR 4/3) light clay loam; weak, medium, subangular blocky structure; slightly firm when moist.

B_3 27 to 35 inches, dark yellowish-brown (10YR 4/4) heavy loam; weak, medium, subangular blocky structure to massive; friable when moist.

C_1 35 to 72 inches, yellowish-brown (10YR 5/6) loam; massive; friable when moist.

C_2 72 inches+, light yellowish-brown (10YR 6/4) loam; massive; calcareous; friable when moist.

loam to loam. The texture of the B_2 horizon ranges from light to medium clay loam.

The LeSueur soils differ from the Nicollet soils in having a thinner A_1 horizon, a weak A_2 horizon, and a finer textured B horizon.

LeSueur loam (SW¼NE¼ sec. 18, T. 93 N., R. 30 W.):

A_1 0 to 6 inches, black (10YR 2/1) heavy loam; moderate, medium, granular structure; friable when moist; slightly acid; gradual boundary.

A_2 6 to 10 inches, very dark gray (10YR 3/1) silt loam; gray 10YR 5/1, dry) coatings; weak, thin, platy and weak, fine, subangular blocky structure; slightly acid; friable when moist; gradual boundary.

B_1 10 to 19 inches, mixed very dark gray (10YR 3/1) and dark grayish-brown (2.5Y 4/2) silt loam; weak, fine, subangular blocky structure; slightly acid; slightly firm when moist; gradual boundary.

B_2 19 to 25 inches, mixed very dark grayish-brown (10YR 3/2) and dark grayish-brown (2.5Y 4/2) clay loam; moderate, fine, subangular blocky structure; few, medium, distinct, dark-brown (7.5YR 4/4, moist) mottles; slightly acid; firm when moist; gradual boundary.

B_3 25 to 34 inches, mixed dark grayish-brown (10YR 4/2) and (2.5Y 4/2) light clay loam; weak, medium, subangular blocky structure; few, medium, distinct, strong-brown (7.5YR 5/6) mottles; slightly acid; slightly firm when moist; gradual boundary.

C_1 34 to 50 inches, mixed grayish-brown (2.5Y 5/2) and dark grayish-brown (2.5Y 4/2) loam; massive; neutral; friable when moist.

MARSHAN SERIES

The Marshan series consists of poorly drained soils that developed from medium textured to moderately fine textured outwash materials of Late Wisconsin age. These soils are on terraces or along minor upland streams. They are classified as Wiesenbodens. They are underlain by an unconforming substratum (D horizon) of sand and gravel. Their permeability is moderately slow. The slope range is 0 to 2 percent. In the solum, most of these soils are nearly neutral, but some are alkaline. The native vegetation was swamp grasses and sedges.

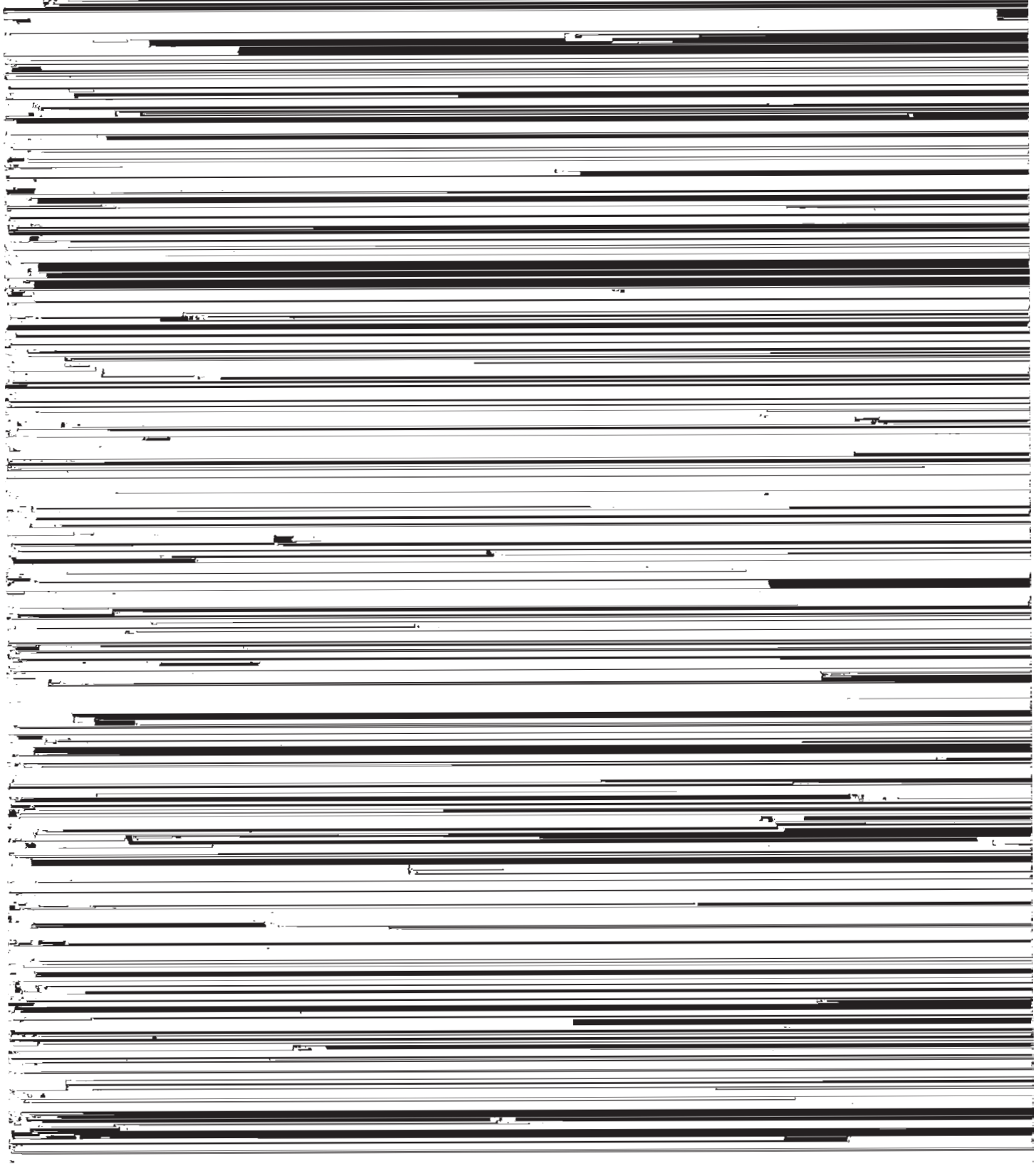
Marshan silty clay loams, deep over sand and gravel.—These soils are underlain by sand and gravel below a depth of 36 inches. The A horizon is 12 to 20 inches thick and ranges in texture from light silty clay loam to heavy silty clay loam. This layer is black (10YR 2/1, 2.5Y 2/0, or 5Y 2/1). The B_g horizon ranges from medium silty clay loam or clay loam to heavy silty clay loam. In areas where there is a C_g horizon, it ranges

B_{g1} 16 to 20 inches, black (5Y 2/2) medium clay loam; moderate, very fine, subangular blocky structure; common, medium, faint, very dark gray (5Y 3/1) mottles; firm when moist; gradual boundary.

B_{g2} 20 to 25 inches, olive gray (5Y 4/2), very dark gray

Two phases of Muck were mapped. Muck, moderately shallow, is 25 to 60 inches deep. Muck, shallow, is 10 to 25 inches deep.

Muck, shallow (100 yards west and 35 yards south of



9 52 to 62 inches, mixed gray (5Y 6/1, moist) and light-gray (5Y 7/2) light silty clay loam; massive; many, coarse, distinct, olive (5Y 5/4, 5/6) mottles; reddish-brown (5YR 4/4) and yellowish-red (5YR 4/6) root channels; calcareous; friable when moist.

NICOLLET SERIES

The Nicollet soils are Brunizems that developed under prairie grasses in the uplands. The parent material is friable, calcareous, Late Wisconsin glacial till of loam texture. The slopes are dominantly convex, but some are concave. The slope range is about 1 to 3 percent. Nicollet soils are imperfectly drained and moderately permeable.

The A_1 horizon is 9 to 16 inches thick. It ranges from loam to light clay loam in texture and from black (10YR 2/1) to very dark brown (10YR 2/2) or very dark gray (10YR 3/1) in color. The texture of the B horizon ranges from heavy loam to light clay loam and is about 3 percent higher in clay content than the A horizon. Generally, the depth to carbonates is about 35 to 40 inches.

The Nicollet soils are not so well drained as the Clarion soils and are not so poorly drained as the Webster soils.

Nicollet loam (NE¼NE¼ sec. 34, T. 93 N., R. 28 W.):

A_1 0 to 9 inches, very dark gray (10YR 3/1) heavy loam; moderate, fine, granular structure; friable when moist.

A_3 9 to 14 inches, very dark gray (10YR 3/1, moist) heavy loam; moderate, medium, granular structure; friable when moist.

B_1 14 to 26 inches, mixed very dark grayish-brown (10YR 3/2) and very dark brown (10YR 2/2, moist) light clay loam; moderate, fine, subangular blocky structure; slightly firm when moist.

B_3 26 to 31 inches, mixed dark grayish-brown (10YR 4/2) and very dark grayish-brown (10YR 3/2 to 2.5Y 3/2) light clay loam; weak, fine, subangular blocky structure; slightly firm when moist.

C_1 31 to 41 inches, mixed dark grayish-brown (2.5Y 4/2 and very dark grayish-brown (2.5Y 3/2) light clay loam; massive; few, fine, distinct, dark-brown (7.5YR 4/2) mottles; slightly firm when moist.

C_2 41 inches+, mixed dark grayish-brown (2.5Y 4/2) and very dark grayish-brown (2.5Y 3/2) loam; massive; few

lowing profile of Okoboji silt loam is presented in table 6, p. 47.

Okoboji silt loam (180 yards west and 30 yards south of the NE corner of NW¼NW¼ sec. 5, T. 93 N., R. 27 W., Vernon Township):

A_{1p} 0 to 5 inches, very dark gray (10YR 3/1, moist) silt loam; weak, medium, granular structure; very friable when moist.

A_{12} 5 to 10 inches, very dark gray (10YR 3/1, moist) silt loam; weak, medium, granular structure; very friable when moist.

A_{13} 10 to 16 inches, black (10YR 2/1, moist) heavy silt loam; moderate, thin, platy structure; friable when moist.

B_{21g} 16 to 21 inches, black (10YR 2/1, moist) silty clay loam; weak, very fine, subangular blocky structure; friable when moist.

B_{22g} 21 to 26 inches, black (5Y 2/1, moist) heavy silty clay loam; moderate, fine, subangular blocky structure; slightly firm when moist.

B_{3g} 26 to 30 inches, black (5Y 2/1, 2/2, moist) silty clay loam; weak, coarse, subangular blocky structure; dark-brown (7.5YR 4/4, moist) root channels; slightly firm when moist.

C_{g1} 30 to 34 inches, gray (5Y 5/1, moist) to dark-gray (5Y 4/1, moist) and very dark gray (5Y 3/1, moist) silty clay loam; massive; dark-brown (7.5YR 4/4, moist) root channels; slightly firm when moist.

C_{g2} 34 to 42 inches, gray (5Y 5/1, moist) to olive (5Y 5/3, moist) silt loam; massive; yellowish-red (5YR 4/6, moist) iron concretions that are 1½ inches in diameter and appear to run in horizontal veins; calcareous; friable when moist.

C_{g22} 42 to 49 inches, gray (5Y 5/1, moist) to olive (5Y 5/4, 5/6, moist) silt loam; massive; common, fine, distinct, light olive-brown (2.5Y 5/6, moist) mottles; calcareous; friable when moist.

OKOBOJI SERIES, IMPERFECTLY DRAINED VARIANT

These are dark-colored soils that developed under grass, in depressions that appear to be sinkholes and are filled with colluvium. The soils are classified as Brunizems that intergrade to Alluvial soils. They occur only in small areas in general soil area 3 in the southwestern part of the county where limestone bedrock is nearer the surface

outwash or reworked glacial till and outwash materials. These soils are poorly drained and slowly permeable. They are in depressions on the upland till plain, generally near the major streams. Unlike some of the other soils in depressions, these soils are not rimmed by the calcareous Harpster soils.

The A horizons vary in texture from light silt loam to sandy loam. Fine sandy loam predominates. The B_g horizons are sandy clay, sandy clay loam, or medium clay loam. In some places there are two or three B_g horizons, separated by layers of loamy sand. The C horizon is highly stratified glacial drift containing layers of silt, coherent sand, and loam.

The A and B horizons are sandier than those in the Rolfe soils.

Orio fine sandy loam (SE¼SW¼ sec. 5, T. 92 N., R. 30 W.):

- A_1 0 to 8 inches, black to very dark gray (10YR 2.5/1) fine sandy loam; weak, fine, granular structure; strongly acid; friable when moist; clear boundary.
- A_{21} 8 to 12 inches, very dark gray (10YR 3/1) and gray (10YR 5/1, dry) sandy loam; moderate, thin, platy structure; friable when moist; strongly acid; gradual boundary.
- A_{22} 12 to 16 inches, dark-gray (10YR 4/1) and gray (10YR 6/1, dry) sandy loam; weak, medium, platy structure; medium acid; friable when moist; clear boundary.
- $A_{23}B_1$ 16 to 20 inches, very dark gray to dark gray (10YR 3.5/1) or gray (10YR 6/1, dry) light loam; weak, medium, platy structure; slightly firm when moist; medium acid; clear boundary.
- A_{g21} 20 to 26 inches, mixed very dark gray to dark-gray

Plattville loam (NE¼NE¼ sec. 11, T. 91 N., R. 30 W.):

- A_1 0 to 10 inches, black (10YR 2/1) loam; weak, fine, granular structure; medium acid; friable when moist; gradual boundary.
- A_{12} 10 to 15 inches, mixed black (10YR 2/1) and very dark gray (10YR 3/1) loam; weak, granular structure; medium acid; friable when moist; gradual boundary.
- B_1 15 to 24 inches, very dark grayish-brown (2.5Y 3/2) light clay loam; very weak, fine, subangular blocky structure; slightly acid; friable when moist; gradual boundary.
- B_{22} 24 to 30 inches, dark grayish-brown (2.5Y 4/2) light clay loam; weak, fine, subangular blocky structure; slightly acid; slightly firm when moist; gradual boundary.
- B_{23} 30 to 42 inches, dark grayish-brown (10YR 4/2) heavy loam; very weak, fine, subangular blocky structure; neutral; friable when moist; gradual boundary.
- B_3 42 to 48 inches, brown (10YR 5/3) loam; massive; common, fine, prominent, strong-brown (7.5YR 5/8) mottles; neutral; friable when moist; abrupt boundary.
- D 48 inches+, brownish-yellow (10YR 6/6) decomposed limestone and limestone fragments in a layer 2 inches thick over limestone.

ROLFE SERIES

In the Rolfe series are very poorly drained soils that developed under swamp grasses and sedges from calcareous glacial drift of Late Wisconsin age. They are classified as Planosols. They are found throughout the county, in potholes or other depressions on the upland till plain. Unlike some other soils in similar positions, they are not rimmed, or surrounded, by the Harpster soils. The Rolfe soils are very poorly drained, slowly to very slowly per-

fine, prominent, yellowish-red (5YR 5/8) iron mottles; clayskins present; very firm when moist.

B_{g22} 26 to 29 inches, olive-gray (5Y 4/2 to 5/2) heavy silty clay loam; moderate, medium, subangular blocky structure; common, fine, distinct, yellowish-red (5YR 5/8) iron mottles; clayskins present; very firm when moist.

B_{g23} 29 to 36 inches, olive-gray (5Y 5/2) clay; moderate, medium, subangular blocky structure; common, fine, distinct, yellowish-red (5YR 5/8) iron mottles; black (5Y 2/1) material in root channels and crayfish holes; clayskins present; very firm when moist.

B_{g31} 36 to 41 inches, olive-gray (5Y 5/2, 5/4) light clay loam; massive with some vertical cleavage planes; common, fine, distinct, yellowish-red (5YR 5/8) iron mottles; black

that range from 0 to 9 percent. They are in the uplands, at the base of stronger slopes, and between the uplands and the stream terraces, at the base of sharp slopes. The principal native vegetation was prairie grasses.

The A horizon is 15 to 30 inches thick. It is medium to heavy loam and is very dark gray (10YR 3/1) to very dark brown (10YR 2/2). In some areas where alluvial material has recently been deposited, the surface layer is very dark grayish brown (10YR 3/2). In some places the B horizon is not distinguishable; where it can be seen, it ranges from very dark grayish brown (10YR 3/2) to dark brown (10YR 4/3). The C horizon is dark grayish

distinct, reddish-brown (5YR 4/4) mottles; calcareous; friable when moist; gradual boundary.

C_{12} 52 to 84 inches, gray (5Y 6/1) silt loam; massive; calcareous; friable when moist; clear boundary.

D 84 to 100 inches, coarse sand and gravel, [illegible]

olive gray (5Y 3/2) or dark gray (5Y 4/1) to mottled light olive gray (5Y 6/2). The C horizon is mainly stratified glacial drift composed mostly of silt loam and very small amounts of fine sand.

B_2 20 to 25 inches, very dark grayish-brown (10YR 3/2) light clay loam; weak, fine and medium, subangular blocky structure; friable when moist; gradual boundary.

B_3 25 to 30 inches, dark-brown (10YR 3/3) sandy clay loam; weak, medium, subangular blocky structure; some fine gravel; friable when moist; gradual boundary.

C_1 30 to 36 inches, mixed dark-brown (10YR 3/3) and brown (10YR 4/3) sandy loam; massive; some fine gravel; very friable when moist; clear boundary.

D_1 36 to 40 inches, sandy loam containing fine, medium, and coarse gravel; massive; loose when moist.

Waukegan loams, moderately deep over sand and gravel.—These soils are underlain by sand and gravel at depths of 24 to 30 inches. The soils are somewhat excessively drained and have moderately rapid permeability.

The slopes range from 0 to 15 percent. The A_1 horizon ranges from 6 to 10 inches in thickness, from light loam to silt loam in texture, and from very dark gray (10YR 3/1) to very dark grayish brown (10YR 3/2) in color. The B horizon, 10 to 20 inches thick, is dark brown (7.5YR 4/4 to 10YR 3/3). In texture the B horizon ranges from sandy clay loam to loam in the upper part to loam or sandy loam in the lower part. The D horizon consists of fine, medium, and coarse gravel and, in some places, contains layers of fine and coarse sand. The gravel commonly contains many shale fragments. The Waukegan soils are not so sandy in the A and B horizons

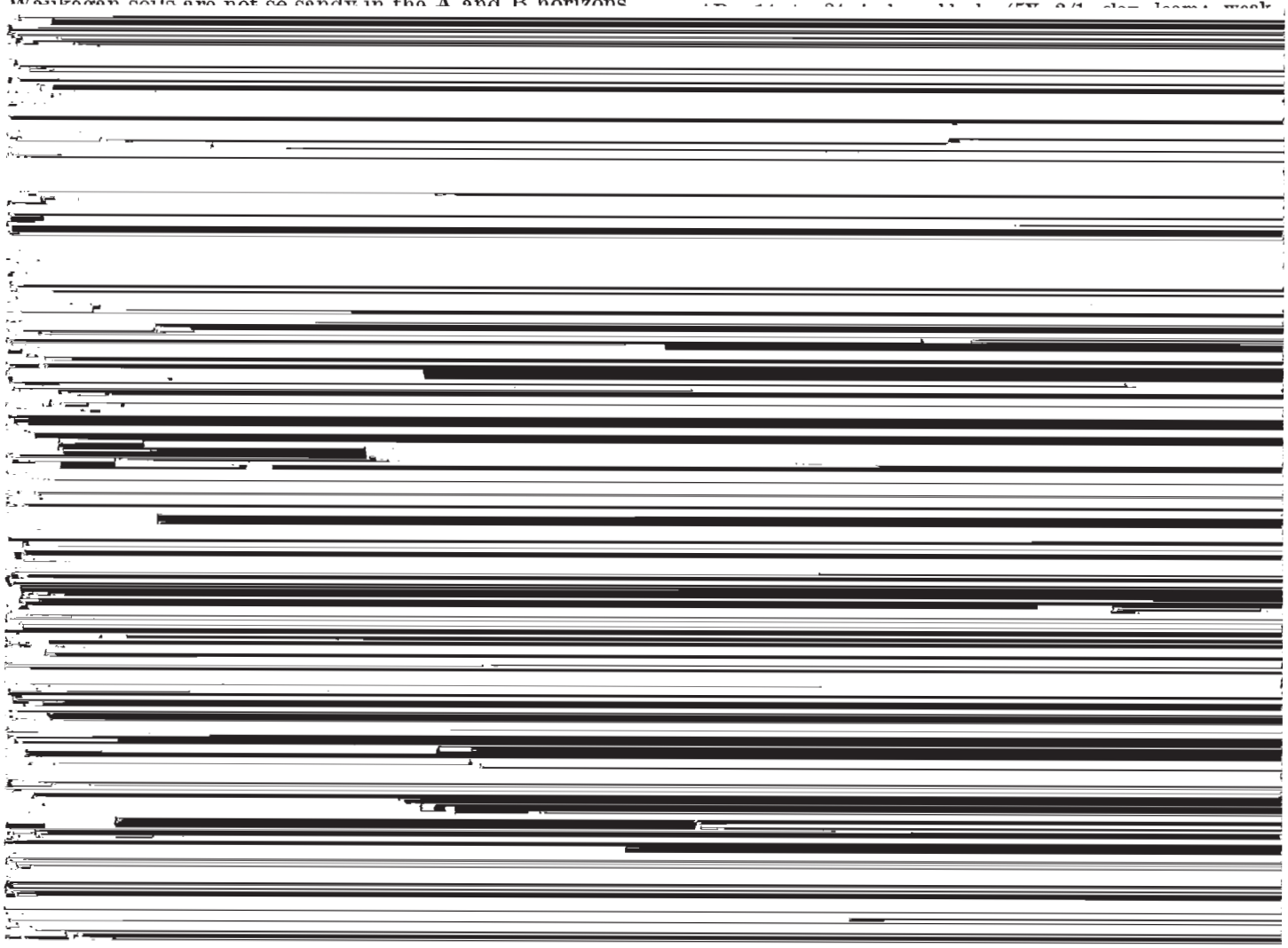
loam in texture and are normally dark gray (10YR 4/1) to olive gray (5Y 5/2) in color. The C horizon is mottled grayish brown (2.5Y 5/2) to pale olive (5Y 6/3). Generally, it is composed of stratified material containing lenses of silt, coherent sand, or sandy loam. Slightly firm glacial till is normally at depths of 40 to 60 inches. In Humboldt County, probably only a few of the Webster soils developed wholly in glacial till. Webster soils that developed in stratified material are dominant and they are normally in slightly concave positions. Detailed studies of textural variations in similar soils have been made by White (*20*).

The Webster soils differ from the Marshan soils in having predominantly medium textured, stratified parent material over glacial till. The Marshan soils are underlain by coarse-textured, stratified material.

Laboratory data for a representative profile are presented in table 8, p. 48.

Webster silty clay loam that developed in stratified material (Southeast corner of section 29, T. 93 N., R. 27 W.):

A_1 0 to 14 inches, black (10YR 2/1) light silty clay loam to clay loam; moderate, fine granular structure; friable; noncalcareous.



B_{g2} 20 to 30 inches, mixed very dark grayish-brown (2.5Y 3/2) and black (2.5Y 2/0) clay loam; weak, very fine, sub-

Soil: The natural medium for the growth of land plants

Although frost heaving and perched water tables are problems, the hilly to rolling Storden, Hayden, and Clarion soils are texturally the better glacial soils for highway construction. In contrast, the level to nearly level Nicollet and Webster soils have a thick, dark-colored surface soil that is commonly more than 2 percent organic carbon. Good density of these dark surface layers is difficult, if not impossible, to attain, even with control

Soil Properties Affecting Conservation Engineering

This subsection discusses soil properties in relation to construction of terraces, drainage and irrigation systems, control of gullying, and farm ponds.

Terraces

TABLE 9.—*Characteristics*

Soil series and miscellaneous land types	Slope	Brief description of soil profile and ground condition	Parent material
	Percent		
Alluvial land (Ad)	0 to 2	Extremely variable	Stratified recent alluvium
Ames (Am)	0 to 1	Poorly drained; firm silty clay loam to clay subsoil over loam material.	Glacial till
Ankeny (AnB, AnC)	2 to 9	Well drained to excessively drained; friable sandy loam to light sandy clay loam subsoil over loamy sand to sandy loam.	Sandy colluvium
Clarion (CaB, CaB2, CaC, CaC2, CaD2, CaE2, CaF2, CaG, CnB, CnC2).	2 to 50	Well drained; friable loam subsoil over calcareous loam parent material; small sand and gravel pockets may occur.	Glacial till
Colo (Co, Cp, Cr, Cs, see also CtB and CtC).[1]	0 to 2	Poorly drained; slightly firm silty clay loam subsoil; underlain in many areas by loamy sand to sand below a depth of 45 inches; high organic-matter content in top 1½ to 2 feet.	Alluvium
Copas (Cv)	0 to 2	Well drained; friable loam subsoil; limestone bedrock at depths of 18 to 30 inches.	Alluvium over bedrock
Cullo (Cu)	0 to 1	Poorly drained; firm silty clay loam subsoil over friable stratified glacial material; high organic-matter content in top 1½ to 2 feet.	Waterworked glacial till
Dickinson (DkA, DkB, DkC2, DkD2, DkE3).	0 to 20	Excessively drained; very friable sandy loam subsoil over sand or loamy sand.	Eolian sands or sandy glacial deposits.
Dickinson, bench position (DtA, DtB, DtC2, DtD2).	2 to 15	Excessively drained; very friable sandy loam subsoil over sand and gravel.	Sandy alluvium
Dundas (Du)	0 to 1	Poorly drained; firm silty clay loam to light silty clay subsoil over loam material; high organic-matter content in top 1½ to 2 feet.	Glacial till
Farrar (FaB, FaC2, FaD2)	2 to 15	Somewhat excessively drained; very friable sandy loam subsoil over loam glacial till at depths of 14 to 40 inches.	Eolian sands over glacial till
Garmore (Ga)	1 to 3	Moderately well drained; slightly firm loam to clay loam subsoil over calcareous loam glacial till; limestone bedrock ordinarily at depths of 10 to 20 feet but, in a few places, the depth is less.	Glacial till
Glencoe (Gc)	0	Very poorly drained; occurs in depressions; firm silty clay loam to light silty clay subsoil over calcareous loam to silt loam; high organic-matter content to	Waterworked glacial till or local alluvium.

that affect soil engineering

Depth to seasonally high water table	Suitability as source of—		Engineering classification	
	Topsoil	Borrow for highway construction	AASHO	Unified
Feet				
0 to 3	Variable	Variable to poor	A–2 to A–7	SM to CH.
1½ to 3	Fair to depth of dark surface layer.	Poor	A–6 to A–7	CL to CH.
5+	Poor	Good	A–2 to A–3	SP to SM.
5+	Good to depth of dark surface layer.	Good	A–4 to A–6	SC to CL.
1 to 3	Good	Unsuitable	A–7	OH to CH.
5+	Fair to depth of dark surface layer.	Fair	A–6 to A–7	CL.
1 to 3	Fair to depth of dark surface layer.	Unsuitable	A–6 to A–7	CL to OH.
5+	Poor	Good	A–2 to A–4	SM to SC.
5+	Poor	Excellent	A–1 to A–2	SM to SP.
1½ to 3	Fair to depth of dark surface layer.	Unsuitable	A–6 to A–7	CH to OH.
5+	Poor	Good	A–2 to A–4	SM to SC.
5+	Good to depth of dark surface layer.	Fair	A–6 to A–7	CL to CH.
0 to 3	Fair to good	Unsuitable	A–7	CH to OH.
1½ to 3	Poor	Unsuitable	A–6 to A–7	CL to OH.
1½ to 3	Poor	Unsuitable above gravel	A–6 to A–7 over A–1 or A–2	CL to OH over SP to GM.
5+	Poor	Good	A–4 to A–6	SC to CL.
1 to 3	Good	Fair to poor	A–6 to A–7	CL to CH.
2½ to 3	Good to depth of dark surface layer.	Excellent below topsoil	A–4 over A–1 to A–2	SC over SC to SW.
5+	Unsuitable	Excellent	A–1 to A–2	GP to SM.
5+	Unsuitable	Good	A–2, A–3, or A–4	SM to SP.
5+	Fair to depth of dark surface layer.	Good	A–4 to A–6	SC to CL.
3+	Fair to depth of dark surface layer.	Fair	A–6 to A–7	SC to CL.
1½ to 3	Good to depth of dark surface layer.	Unsuitable above gravel	A–6 to A–7 over A–1 or A–2.	CL to OH over GP to SM.
0 to 3	Good to excellent	Unsuitable	Visual	Pt.
3+	Good to depth of dark surface layer.	Fair	A–6 to A–7	SC to CL.

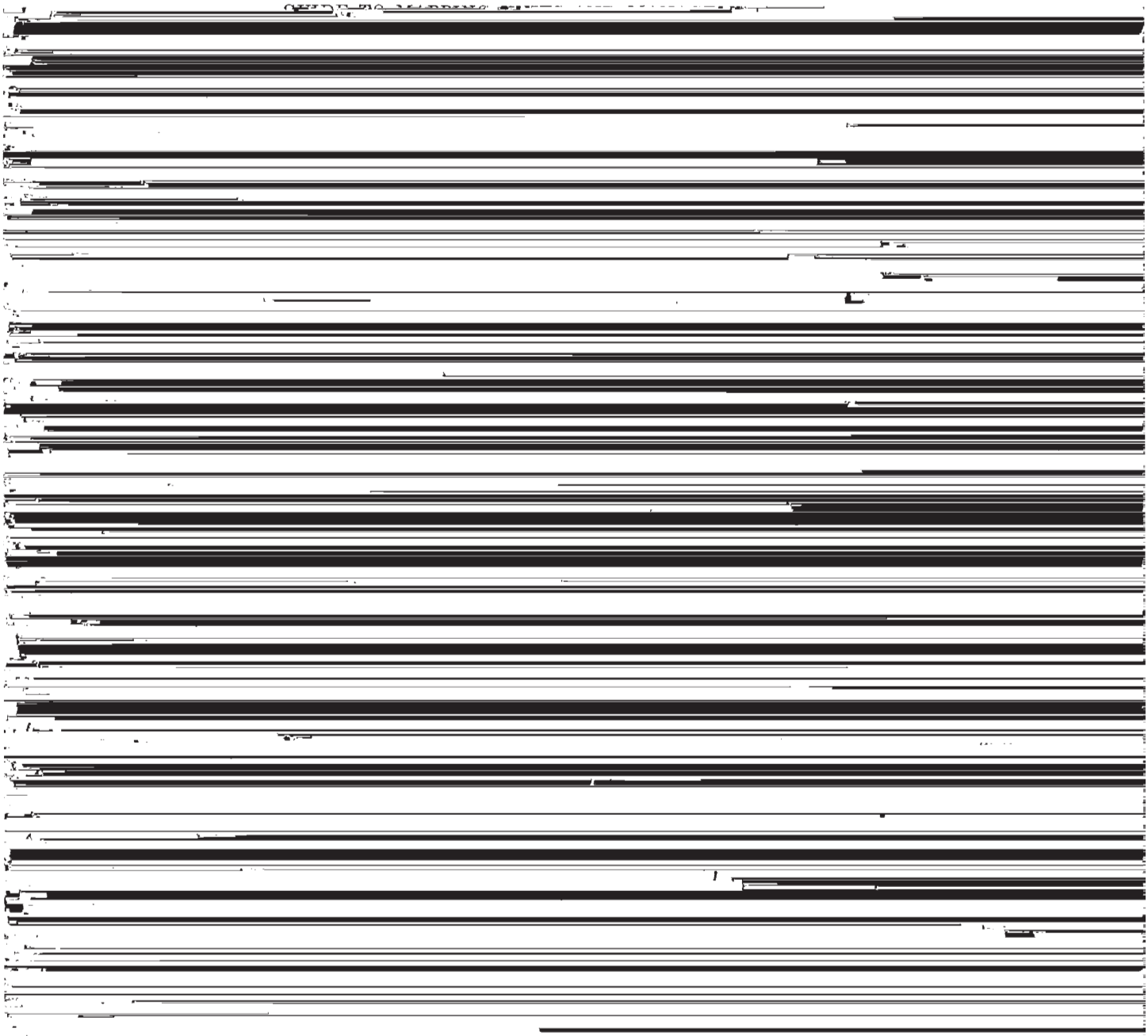
TABLE 9.—*Characteristics that*

Soil series and miscellaneous land types	Slope	Brief description of soil profile and ground condition	Parent material
	Percent		
Okoboji (Ok, Op)	0	Imperfectly to very poorly drained; slightly firm silty clay loam subsoil over silt loam to silty clay loam material.	Waterworked glacial till or local alluvium.
Orio (Or)	0	Poorly drained; firm sandy clay to clay loam subsoil over highly stratified glacial drift containing layers of silt, sand, and loam.	Stratified glacial drift
Plattville (Pv)	0 to 2	Imperfectly drained; slightly firm or friable loam or clay loam subsoil over limestone bedrock at depths of 36 to 60 inches.	Alluvium over limestone
Rolfe (Ro)	0	Very poorly drained; very firm clay to clay loam subsoil over highly stratified glacial drift containing layers of silt, sand, and loam.	Waterworked glacial till or local alluvium.

affect soil engineering—Continued

Depth to seasonally high water table	Suitability as source of—		Engineering classification	
	Topsoil	Borrow for highway construction	AASHO	Unified
Feet 0 to 3	Good	Unsuitable	A–7 to peat or muck	OH to Pt.
0 to 3	Poor	Poor	A–6 to A–7	SC to CH.
5+	Good to depth of dark surface layer.	Fair	A–6 to A–7	CL.
0 to 3	Fair to depth of dark surface layer.	Poor	A–6 to A–7	CL to OH.
5+	Unsuitable	Unsuitable	Variable	Variable.
5+	Unsuitable	Good	A–4 to A–6	SC to CL.

(12) RUHE, ROBERT V.
1952. TOPOGRAPHIC DISCONTINUITIES OF THE DES MOINES LOBE. Amer. Jour. Sci. 250: 46–56, illus.
(13) RUHE, R. V., RUBIN, MEYER, and SCHOLTES, W. H.
1957. LATE PLEISTOCENE RADIOCARBON CHRONOLOGY IN IOWA. Amer. Jour. Sci. 255: 671–689, illus.
(14) RUHE, R. V. and SCHOLTES, W. H.
1956. AGES AND DEVELOPMENT OF SOIL LANDSCAPES IN RELATION TO CLIMATIC AND VEGETATIONAL CHANGES IN IOWA. Soil Sci. Soc. Amer. Proc. 20: 264–273, illus.
(15) ———
1955. RADIOCARBON DATES IN CENTRAL IOWA. Jour. Geol. 63: 82–92, illus.
(16) THORP, JAMES and SMITH, GUY D.
1949. HIGHER CATEGORIES OF SOIL CLASSIFICATION: ORDER, SUBORDER, AND GREAT SOIL GROUPS. Soil Sci. 67: 117–126.
(17) SIMONSON, G. H., PRILL, R. C., and RIECKEN, F. F.
1957. FREE IRON DISTRIBUTION IN SOME POORLY DRAINED PRAIRIE SOILS IN IOWA. Iowa Acad. Sci. 64: 385–392.
(18) SIMONSON, R. W., RIECKEN, F. F., and SMITH, GUY D.
1952. UNDERSTANDING IOWA SOILS. 142 pp., illus.
(19) WATERWAYS EXPERIMENT STATION, CORPS OF ENGINEERS, UNITED STATES ARMY.
1953. UNIFIED SOIL CLASSIFICATION SYSTEM. Tech. Memo. 3–357, v. 1, 39 pp.
(20) WHITE, EVERETT M.
1953. SUBSOIL TEXTURE VARIATIONS ON THE CLARION-WEBSTER EXPERIMENTAL FARM AS RELATED TO THE MANKATO GLACIAL DEPOSIT. Iowa Acad. Sci. 60: 438–441.



Map symbol	Mapping unit	Page	Management group	Page
LfC2	Lamont fine sandy loam, 5 to 9 percent slopes, moderately eroded	16	10	42
LfD2	Lamont fine sandy loam, 9 to 15 percent slopes, moderately eroded	16	13	43
LfE2	Lamont fine sandy loam, 15 to 20 percent slopes, moderately eroded	17	17	44
LmB	Lester loam, 2 to 5 percent slopes	17	6	41
LmC2	Lester loam, 5 to 9 percent slopes, moderately eroded	17	11	43
LmD2	Lester loam, 9 to 15 percent slopes, moderately eroded	17	12	43
LmE2	Lester loam, 15 to 20 percent slopes, moderately eroded	17	14	44
LsF	Lester soils, 20 to 30 percent slopes	17	16	44
LsG	Lester soils, 30 to 50 percent slopes	17	18	45
Lu	LeSueur loam	17	1	39
Md	Marshan silty clay loam, deep over sand and gravel	18	3	40
Mm	Marshan silty clay loam, moderately deep over sand and gravel	18	3	40
Mu	Muck, moderately shallow	18	8	42
Mw	Muck, shallow	18	8	42
Mx	Mucky peat, deep	18	8	42
My	Mucky peat, moderately shallow	18	8	42
Mz	Mucky peat, shallow	18	8	42
Nc	Nicollet loam	19	1	39
Ok	Okoboji silt loam	19	7	41
Op	Okoboji silt loam, imperfectly drained variant	19	3	40
Or	Orio fine sandy loam	19	7	41
Pv	Plattville loam	20	1	39
Ro	Rolfe loam	20	7	41
SgB	Sogn loam, 2 to 5 percent slopes	20	13	43
StD2	Storden loam, 9 to 15 percent slopes, moderately eroded	20	12	43
StE2	Storden loam, 15 to 20 percent slopes, moderately eroded	21	14	44
StF3	Storden loam, 20 to 30 percent slopes, severely eroded	21	16	44
StG3	Storden loam, 30 to 50 percent slopes, severely eroded	21	18	45
TeA	Terril loam, 0 to 2 percent slopes	21	1	39
TeB	Terril loam, 2 to 5 percent slopes	21	6	41
TeC	Terril loam, 5 to 9 percent slopes	21	11	43
TrA	Truman silt loam, 0 to 2 percent slopes	21	1	39
TrB	Truman silt loam, 2 to 5 percent slopes	21	6	41
TrC2	Truman silt loam, 5 to 9 percent slopes, moderately eroded	21	11	43
TrD2	Truman silt loam, 9 to 15 percent slopes, moderately eroded	21	12	43
TrE2	Truman silt loam, 15 to 20 percent slopes, moderately eroded	21	14	44
Wa	Wabash silty clay	22	7	41
Wb	Wabash silty clay, channeled	22	15	44
Wc	Wacousta silt loam	22	7	41
WdA	Waukegan loam, deep over sand and gravel, 0 to 2 percent slopes	23	1	39
WdB	Waukegan loam, deep over sand and gravel, 2 to 5 percent slopes	23	6	41
WdC2	Waukegan loam, deep over sand and gravel, 5 to 9 percent slopes, moderately eroded	23	11	43
WmA	Waukegan loam, moderately deep over sand and gravel, 0 to 2 percent slopes	22	5	41
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